IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REQUEST FOR FILING NATIONAL PHASE OF PCT APPLICATION UNDER 35 U.S.C. 371 AND 37 CFR 1.494 OR 1.495

To: Hon. Commissioner of Patents
Washington, D.C. 20231

00909

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

Atty Dkt: P 290511 /RP-00864-US1
M# /Client Ref.

From: Pillsbury Winthrop LLP, IP Group:

Date: February 11, 2002

This is a **REQUEST** for FILING a PCT/USA National Phase Application based on:

1. International Application	2. International Filing Date	3. Earliest Priority Date Claimed
PCT/EP00/07210	26 July 2000	11 August 1999
⇧ country code	Day MONTH Year	Day MONTH Year (use item 2 if no earlier priority)

4. Measured from the earliest priority date in item 3, this PCT/USA National Phase Application Request is being filed within:

(a) ☐ 20 months from above item 3 date (b) ☒ 30 months from above item 3 date,

(c) Therefore, the due date (unextendable) is February 11, 2002

5. Title of Invention DEVICE FOR DELIVERING AND/OR SPRAYING FLOWABLE MEDIA, ESPECIALLY FLUIDS

6. Inventor(s) Wolfram HELLMICH, Klaus-Jurgen PETER, Robert KOTTER, Liang ZHANG

Applicant herewith submits the following under 35 U.S.C. 371 to effect filing:

7. ☒ Please immediately start national examination procedures (35 U.S.C. 371 (f)).

8. ☒ **A copy of the International Application** as filed (35 U.S.C. 371(c)(2)) is transmitted herewith (file if in English but, if in foreign language, file only if not transmitted to PTO by the International Bureau) including:

a. ☐ Request;
b. ☒ Abstract;
c. 31 pgs. Spec. and Claims;
d. 3 sheet(s) Drawing which are ☐ informal ☒ formal of size ☒ A4 ☐ 11"

9. ☒ **A copy of the International Application has been transmitted by the International Bureau.**

10. **A translation of the International Application** into English (35 U.S.C. 371(c)(2))

a. ☐ is transmitted herewith including: (1) ☐ Request; (2) ☐ Abstract;
(3) ______ pgs. Spec. and Claims;
(4) ______ sheet(s) Drawing which are:
☐ informal ☐ formal of size ☐ A4 ☐ 11"

b. ☐ is not required, as the application was filed in English.

c. ☒ is not herewith, but will be filed when required by the forthcoming PTO Missing Requirements Notice per Rule 494(c) if box 4(a) is X'd or Rule 495(c) if box 4(b) is X'd.

d. ☐ Translation verification attached (not required now).

RE: USA National Phase Filing of PCT /EP00/07210

11. ☒ Please see the attached Preliminary Amendment

12. ☐ Amendments to the claims of the International Application **under PCT Article 19 (35 U.S.C. 371(c)(3)), i.e., before 18th month from first priority date above in item 3, are transmitted herewith (file only if in English) including:**

13. ☒ PCT Article 19 claim amendments (if any) have been transmitted by the International Bureau

14. ☐ Translation of the amendments to the claims **under PCT Article 19 (35 U.S.C. 371(c)(3)), i.e., of claim amendments** made before 18th month, **is attached (required by 20th month from the date in item 3 if box 4(a) above is X'd, or 30th month if box 4(b) is X'd, or else amendments will be considered canceled).**

15. **A declaration of the inventor** (35 U.S.C. 371(c)(4))
   a. ☐ is submitted herewith ☐ Original ☐ Facsimile/Copy
   b. ☒ is not herewith, but will be filed when required by the forthcoming PTO Missing Requirements Notice per Rule 494(c) if box 4(a) is X'd or Rule 495(c) if box 4(b) is X'd.

16. **An International Search Report (ISR):**
   a. Was prepared by ☒ European Patent Office ☐ Japanese Patent Office ☐ Other
   b. ☒ has been transmitted by the international Bureau to PTO.
   c. ☒ copy herewith (2 pg(s).) ☒ plus Annex of family members (1 pg(s).).

17. **International Preliminary Examination Report** (IPER):
   a. ☒ has been transmitted (if this letter is filed after 28 months from date in item 3) in English by the International Bureau with Annexes (if any) in original language.
   b. ☐ copy herewith in English.
   c.1 ☐ IPER Annex(es) in original language ("Annexes" are amendments made to claims/spec/drawings during Examination) including attached amended:
   c.2 ☐ Specification/claim pages #___ claims #
   Dwg Sheets #
   d. ☐ Translation of Annex(es) to IPER **(required by 30th month due date, or else annexed amendments will be considered canceled).**

18. **Information Disclosure Statement** including:
   a. ☐ Attached Form PTO-1449 listing documents
   b. ☐ Attached copies of documents listed on Form PTO-1449
   c. ☒ A concise explanation of relevance of ISR references is given in the ISR.

19. ☐ **Assignment** document and Cover Sheet for recording are attached. Please mail the recorded assignment document back to the person whose signature, name and address appear at the end of this letter.

20. ☐ Copy of Power to IA agent.

21. ☐ **Drawings** (complete only if 8d or 10a(4) not completed): _ sheet(s) per set: ☐ 1 set informal; ☐ Formal of size ☐ A4 ☐ 11"

22. Small Entity Status ☒ is **Not** claimed ☐ is claimed (pre-filing confirmation required)
22(a) ___ (No.) Small Entity Statement(s) enclosed (since 9/8/00 Small Entity Statements(s) not essential to make claim)

23. **Priority** is hereby claimed under 35 U.S.C. 119/365 based on the priority claim and the certified copy, both filed in the International Application during the international stage based on the filing in (country) GERMANY of:

	Application No.	Filing Date		Application No.	Filing Date
(1)	199 37 988.2	11 August 1999	(2)		
(3)			(4)		
(5)			(6)		

   a. ☒ See Form PCT/IB/304 sent to US/DO with copy of priority documents. If copy has not been received, please proceed promptly to obtain same from the IB.
   b. ☐ Copy of Form PCT/IB/304 attached.

RE: USA National Phase Filing of PCT/EP00/07210

24. Attached:

25 Per Item 17.c2, **cancel original** pages #___, claims #___, Drawing Sheets #

26. **Calculation of the U.S. National Fee (35 U.S.C. 371 (c)(1)) and other fees is as follows:**

Based on amended claim(s) per above item(s) ☐ 12, ☐ 14, ☐ 17, ☐ 25 (hilite)

Total Effective Claims	minus 20 =	x $18/$9 =	$0	966/967
Independent Claims	minus 3 =	x $84/$42 =	$0	964/965
If any proper (ignore improper) Multiple Dependent claim is present,		add$280/$140	+0	968/969

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(4)): →→ **BASIC FEE REQUIRED, NOW** →→→→

A. If country code letters in item 1 are **not** "US","BR","BB","TT","MX","IL" "NZ", "IN" or "ZA"

See item 16 re:

1. Search Report was not prepared by EPO or JPO - - - - - - - - -	add$1,040/$520		960/961
2. Search Report was prepared by EPO or JPO - - - - - - - - - - - -	add$890/$445	+890	970/971

SKIP B, C, D AND E UNLESS country code letters in item 1 are "US","BR","BB","TT","MX","IL", "NZ", "IN", "ZA", "LC" or "PH"

→ (X)	☐ B.	If USPTO did not issue both International Search Report (ISR) and (if box 4(b) above is X'd) the International Examination Report (IPER), - - - - - - - - - - - - - - - - - - -	add$1,040/$520	+0	960/961
(only) (one)→ (of)	☐ C.	If USPTO issued ISR but not IPER (or box 4(a) above is X'd), -	add$740/$370	+0	958/959
(these) (4)→ (boxes)	☐ D.	If USPTO issued IPER but IPER Sec. V boxes not all 3 YES, -	add$710/$355	+0	956/957
→	☐ E.	If international preliminary examination fee was paid to USPTO and Rules 492(a)(4) and 496(b) satisfied (in IPER Sec. V all 3 boxes must be YES for all claims), - -	add $100/$50	+0	962/963

27. **SUBTOTAL =** $890

28. If Assignment box 19 above is X'd, add Assignment Recording fee of ----$40 +0 (581)

29. If box 15a is x'd, determine whether inventorship on Declaration is different than in international stage. If yes, add (per Rule 497(d) ----$130 +0 (098)

30. Attached is a check to cover the - **TOTAL FEES** $890

Our Deposit Account No. 03-3975

Our Order No. 009919 (C#) | 0290511 (M#)

00909

CHARGE STATEMENT: The Commissioner is hereby authorized to charge any fee specifically authorized hereafter, or any missing or insufficient fee(s) filed, or asserted to be filed, or which should have been filed herewith or concerning any paper filed hereafter, and which may be required under Rules 16-18 and 492 (missing or insufficient fee only) now or hereafter relative to this application and the resulting Official document under Rule 20, or credit any overpayment, to our Account/Order Nos. shown above for which purpose a duplicate copy of this sheet is attached.

This CHARGE STATEMENT does not authorize charge of the issue fee until/unless an issue fee transmittal form is filed

Pillsbury Winthrop LLP
Intellectual Property Group
By Atty: Paul T. Bowen **Reg. No.** 38009
Sig: [signature] **Fax:** (703) 905-2500
Atty/Sec: PTB/jck **Tel:** (703) 905-2020

NOTE: File in duplicate with 2 postcard receipts (PAT-103) & attachments.

PTO/PCT Rec'd 16 AUG 2002 10049243 . 081602

#4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Application of:	
HELLMICH et al.	Confirmation No.: 9400
Serial No.: 10/049243	Art Unit: Unknown
Filing Date: February 11, 2002	Examiner: Unknown
Title: DEVICE FOR DELIVERING AND/OR SPRAYING FLOWABLE MEDIA, ESPECIALLY FLUIDS	

August 16, 2002

SECOND PRELIMINARY AMENDMENT

Honorable Assistant Commissioner of Patents
Washington, D.C. 20231

Sir:

Before examination of the above-identified patent application, please amend the application as indicated below:

IN THE ABSTRACT:

The Abstract is amended to read as follows:

The invention concerns a device to convey and/or spray free-flowing media, in particular fluids, which works in accordance with the energy storage principle and is designed as an electromagnetically-powered reciprocating pump with at least one armature device as a drive element, whereby the armature device includes at least two armature elements and the armature elements are assigned magnetically corresponding yoke elements.

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IN THE SPECIFICATION:

At page 1, before the first line of the specification and after the Title, delete the paragraph inserted by the Preliminary Amendment filed on February 11, 2002, and insert the following paragraph and heading:

This is a National Phase entry from PCT Patent Application Serial No. PCT/EP00/07210, filed on July 26, 2000, which designated the United States. The PCT Patent Application was not published under PCT Article 21(2) in English. This application relies for priority on German Patent Application No. 199 37 988.2, filed on August 11, 1999. Both applications are incorporated herein by reference.

Field of the Invention

At page 1, before the second full paragraph beginning on line 7, insert the following heading:

Description of the Related Art

At page 2, before the third full paragraph beginning on line 10, insert the following heading:

Summary of the Invention

At page 2, the third full paragraph is amended as follows:

This results in increasing demands on the injection systems of these internal combustion engines with respect to the flow rates per working cycle and with respect to the volume flow (i.e., fluid flow rate per unit of time).

At page 2, the fourth full paragraph is amended as follows:

This increased flow rate per working cycle and the increased volume flow can be achieved, for example, by enlarging the electromagnets, though these then also have a higher electrical power consumption. But this entails additional costs not only for the larger elements but also, and above all, for generators and control circuits for the electromagnets that are more powerful.

At page 3, the first full paragraph is amended as follows:

It is, therefore, one aspect of the invention to provide a device that resolves the deficiencies in the art.

At page 4, the third full paragraph is amended as follows:

A preferred variant of the armature device is designed as a two-armature element device and is surrounded by an armature cylinder with two corresponding yoke elements, e.g., armature cylinder sleeves.

At page 4, the fourth full paragraph is amended as follows:

A particularly preferred variant of the device, in accordance with the invention, works according to the solid body energy storage principle.

At pages 4-5, the carry-over paragraph is amended as follows:

With a device to convey and/or spray free-flowing media, in particular fluids, in accordance with the invention, it is advantageous that, with a given electrical energy supply, the static magnetic force on the armature device is much higher than the state-of-the-art and, thus, the work performed by the armature device along its stroke path is much greater. In this respect,

the energy transmitted by the armature device to the medium to be conveyed or sprayed and, thus, the efficiency of the device in accordance with the invention, is significantly increased. A device in accordance with the invention requires only a small structural space on account of the axially serial arrangement of the armature elements in a magnetic serial connection.

At page 5, before the second full paragraph, the following heading is added:

Brief Description of the Drawings

At page 5, the description of the drawings is amended to read:

Fig. 1 is a longitudinal section through a device in accordance with the invention to convey and/or spray free-flowing media, in particular fluids;

Fig. 2 is a detailed view of the longitudinal section of the device illustrated in Fig. 1; and

Fig. 3 is a diagrammatic view of the flux distribution characteristics of the magnetic lines of force of the device illustrated in Fig. 1.

At page 5, the following heading is inserted before the last full paragraph:

Description of Preferred Embodiment(s) of the Invention

At page 6, the first full paragraph is amended to read as follows:

The drive housing 2 has a thin-walled, cylinder jacket-shaped outside wall 6 and a thin-walled base wall 7 that closes one end of the drive housing 2 so that a drive housing inner space 8 is limited. The base wall 7 has two steps radial to the central longitudinal axis 4. The base wall 7 has a first annular face wall 9 running radially from the outside to the inside, a first annular stepped wall 10 running coaxially to the outside wall 6, a second annular face wall 11 running opposite to the direction of delivery 5 and set back from the first annular face

wall 9, a second annular face wall 12, and a rear final wall 13 axial to the direction of delivery 5. The outside wall 6 includes a recess 14 near the first annular face wall 9 containing a connecting device 15 with contact elements 16 to connect the device 1 to an electricity supply. In the front, open end of the drive housing 2, in the direction of delivery 5, there is a thread 17 on the inner side of the outside wall.

At page 6, the second full paragraph is amended to read as follows:

An essentially cylindrically disk-shaped guide piece 18 sits in the radial inner partial area of the inner side of the second annular face wall 11, so that a base cavity 19 is bordered by the guide piece 18, the second annular face wall 12 and the final wall 13. The guide piece 18 has a central bearing bore 20 with the central longitudinal axis 4 as the bore axis. A number of through bores 21 are arranged radially around the bearing bore 20, parallel to the bearing bore 20, which run into the base cavity 19 on the base side.

At page 6, the third full paragraph is amended to read as follows:

A first cylindrical tube-shaped armature cylinder sleeve 22 that protrudes slightly into the drive housing inner space 8 away from the base wall 7, with the central longitudinal axis 4 as a center axis, sits as a conducting element radially positioned between the guide piece 18 and the first annular stepped wall 10 and axially positioned on the guide piece 18. The first armature cylinder sleeve 22 is made of a very good magnetically conductive material and displays a face 23 on the inner space side from which a small piston land 24 protrudes axially in the direction of delivery 5.

At page 7, the second full paragraph is amended to read as follows:

Analogous to the first annular element 25, a second annular element 31, which has the same three-dimensional shape as the first annular element 25 and is also made of a magnetic nonconducting, non-magnetizable material, e.g. stainless steel, sits on the face 28 of the second armature cylinder sleeve 26 as a spacing element or means to interrupt the magnetic flux.

At page 7, the last paragraph bridging pages 7 and 8, is amended to read as follows:

The armature cylinder sleeves 22, 26, 32 and the annular elements 25, 31 form an armature cylinder 35 with the central longitudinal axis 4 as the central axis, which circumscribes an armature space 41. The armature space 41 is limited on the base wall side by the guide piece 18 and on the pump housing side by the inner ring area 40a of the face 40 of the pump housing 3.

At page 8, the fifth full paragraph is amended to read as follows:

In the space delimited by the walls, 44, 45, 46, there is a magnet coil 47 connected to the contact elements 16 of the connecting device 15.

At page 9, the first full paragraph is amended to read as follows:

The base part 50 is cylindrical disk-shaped and delimited on the base side by the face 40 and the inner area 40a of the face 40 and on the opposite side by a face 55. The base part 50 has a circumferential surface 53 whose base-side end area has a male thread 54 corresponding to the female thread 17 of the drive housing 2. The base part 50 is screwed into the drive housing 2 so far that the armature cylinder sleeves 22, 26, 32 and the annular elements 25, 31 are pressed axially against one another, and this is supported by the guide piece 18 on the

second annular ring wall 11. A sealing ring 55, e.g. an O-ring, is provided to seal off the base cavity 19 and the armature space 41 from the coil space 42, which sits in a sealing channel 56 formed by a base-side face of the first armature cylinder sleeve 32, the first annular ring wall 10, the second annular ring wall 11 and an L-shaped recess in the guide piece 18.

At page 9, the second full paragraph is amended to read as follows:

The base part 50 has a simple stepped- through bore 57 with the central longitudinal axis 4 as the central axis. The stepped-through bore 57 is enlarged on the base side at a location hole 57a, which ends in the armature space 41. At the other end, the stepped-through bore 57 is enlarged by a blind hole bore 58 delimited by the nozzle retaining cylinder 51. It is enlarged compared to the stepped through bore 57.

At page 9, the third full paragraph is amended to read as follows:

In the enlargement of the stepped through bore 57 on the armature space side, there is a positive and non-positive-locked guide cylinder 59 tapered in two steps. The guide cylinder 59 protrudes into the armature space 41 on a level with the inner area 40a forming an annular face 60 and an annular projection 61.

At page 9, the last paragraph bridging pages 9 and 10 is amended as follows:

The guide cylinder 59 displays a stepped through bore 62 corresponding to the bearing bore 20 that has the central longitudinal axis 4 as a central axis. In other words, the guide cylinder 59 is axially aligned with the bearing bore 20 of the guide piece 18. The through bore 62 is enlarged to the diameter of the through bore 57 at its armature space 41 end. Around the inner circumference of the enlarged area of the through bore 62 there are a number of spaced positioning ribs 63 for a valve body 64 that point radially inwards. The valve body 64 rests

in the through bore 57 with play, so that the areas in front of and behind the valve body 64 are hydraulically connected.

At page 10, the first full paragraph is amended to read as follows:

A multiple, tapering, feed bore 65 for the medium to be conveyed or sprayed leads radially from the outer surface 53 of the pump housing 3 and ends in the through bore 57. There is a feed device 66 in the feed bore 65 consisting of a hollow drilled feed nipple 67 and a return valve element 69 positioned radially inwards after this in the feed direction 68 that prevents the medium from flowing opposite to the feed direction 68.

At page 11, the first full paragraph is amended to read as follows:

The pressure space bore 85 and the through bore 87 delimit a pressure space 88 that is sealed on the drive side by the spherical valve body 64 and ends on the nozzle side in the overflow bore 86.

At page 12, the first full paragraph is amended to read as follows:

The device 1 has a standard armature device 100 as a drive element that comprises an armature carrier element 101, e.g. a delivery plunger tube, and a first armature element 102 on the base side. The standard armature device 100 also comprises a second, identical armature element 103 on the pressure space side, positioned at a distance D (Fig. 2) from the first armature element 102.

At page 12, the third full paragraph is amended to read as follows:

The armature carrier element 101 is designed, e.g. as a delivery plunger tube, which is essentially a hollow cylindrical, long stretched-out body that can be moved axially. The armature carrier element 101 is locked positively in a radial direction with its base end 104 in

the bearing bore 20 of the guide piece 18, passing through the armature space 41, and with its pressure space-side end 105 in the bearing bore 62 of the guide cylinder 59. In the starting position, the end 104 protrudes slightly into the base cavity 19, whereby the end 105 is roughly flush with the pressure space-side end of the bearing bore 62 of the guide cylinder 59. The end 105 is located at a slight distance from the valve body 64, which rests on the ribs 63. The armature carrier element 101 has an axial through bore 106 the ends of which are conically enlarged in the manner of a phase. The chamfer of the armature carrier element 101 on the pressure space side forms a valve seat for the valve body 64 so that the armature carrier element 101 and the valve body 64 form a valve with which the armature space 41 can be hydraulically separated from the pressure space 88.

At page 12, the last paragraph bridging pages 12 and 13 is amended to read as follows:

Referring to Fig. 2, the armature elements 102, 103 are located in the armature space and each are essentially, cylindrically ring disk-shaped. Each has a central bore 107 and 108, which have the central longitudinal axis 4 as their central axis. The armature elements 102, 103 sit firmly with the bore 107, 108 on the armature carrier element 101 and have an outer diameter that is slightly smaller than the inner diameter of the armature cylinder sleeves 22, 26, 32, thus forming a radial play gap 109 of the width T. The armature elements 102, 103 thus rest in the armature space 41 with a radial play to the armature cylinder 35 and can be moved in an axial direction. The armature elements 102, 103 are made of a lightweight, magnetizable material and each has at least one overflow bore 110 parallel to the central bores 107, 108.

At page 13, the first full paragraph is amended to read as follows:

The armature element 102 has a face 110a on the base side and face 111 on the pressure space side. The armature element 102 also has a circumferential face 112. The face 111 and the circumferential face 112 form a circumferential edge 113 (see, e.g., Fig. 2). The armature element 103 accordingly has a face 114 on the base side and a face 115 on the pressure space side. It also has a circumferential face 116. The face 115 and the circumferential face 116 form a circumferential edge 117.

At page 13, the second full paragraph is amended to read as follows:

As described above, the face 110 of the first armature element 102 rests on the guide piece 18 on the armature space side in the starting position. The axial longitudinal extension of the armature element 102 is constructed so that it covers the part of the armature cylinder sleeve 22 that delimits the armature space 41 in the axial direction and so that there is a first axial gap 121 with a gap width S_1 between its circumferential edge 113 and the piston land 29 of the second armature cylinder sleeve 26.

At page 14, the first full paragraph is amended to read as follows:

The axial overlap of the armature elements 102, 103 (and the corresponding adjacent armature cylinder sleeves 22 and 26 in the starting position and the respective adjacent annular elements 25 and 31 in the starting position) has been chosen so that the magnetic flux is optimized.

At page 14, the last paragraph bridging pages 14 and 15 is amended to read as follows:

If the coil 47 is supplied with current in the starting position as shown in Fig. 2, magnetic lines of force 130 form toroidally around the coil body (Fig. 3). Depending on the polarity,

they enter the first armature cylinder sleeve 22, e.g. from the base side, the armature element 102 thus bridging the radial gap 18 (the parasitic gap between the armature cylinder sleeve 22 and the first armature element 102). The magnetic lines of force 130 leave the armature element 102 to a large extent in the area of the narrowest point between the armature element 102 and the second armature cylinder sleeve 26 (yoke element). The magnetic lines of force 130 run roughly axially in the second armature cylinder sleeve 26 up to the overlap area of the second armature element 103 and the second armature cylinder sleeve 26. The magnetic lines of force 130 enter the second armature element 103 by bridging the gap 108 (parasitic gap) between the armature cylinder sleeve 26 and the second armature element 103. The magnetic lines of face 130 leave the second armature element 103 in a manner analogous to the first armature element 102 to a large extent at the narrowest point between the second armature element 103 and the third armature cylinder sleeve 32. Finally, the magnetic lines of force 130 enter the third armature cylinder sleeve 32 (see Fig. 3).

At page 15, the first full paragraph is amended to read as follows:

As a result of this, the areas of the armature elements 102 and 103 (faces 111 and 115) and the armature cylinder sleeves 26 and 32 (piston lands 29 and 34) opposite the abovementioned narrow points are magnetized with opposite poles so that static magnetic forces F_{M1} and F_{M2} work on the armature element 102 and the armature element 103. The armature elements 102, 103 thus represent armatures (in the sense of the abovementioned definition) and the armature cylinder sleeve 26, 32 yoke elements (in the sense of the abovementioned definition).

At page 15, the second full paragraph is amended to read as follows:

The total static magnetic force $F_M = F_{M1} + F_{M2}$ that works on the armature device 100 is much higher with the same input of electrical energy, due to the abovementioned magnetic series connection of the armature elements 102, 103 and the corresponding yoke elements 25, 32 than a resulting magnetic force with an armature device that has a single armature element only. Thus, the output of the armature device 100 over a certain distance H along a direction of stroke 123 is correspondingly higher. In this respect, this leads to a better use of the magnetic energy generated by the coil 47 by means of a pre-defined input energy. Thus, the efficiency of a drive device of this type, with a multiple armature device 100 with armature elements 102 and 103 yoke elements corresponding to the armature elements 102 and 103, and thus the overall efficiency of a device 1 in accordance with the invention, is significantly improved.

At page 16, the first full paragraph is amended to read as follows:

The gaps 121 and 122 extend in the working direction (direction of stroke 123) of the armature device 100. The widths S_1 and S_2 of these gaps determine the amount of the static magnetic forces that momentarily occur between the armature elements 102, 103 and the yoke elements (armature cylinder sleeves 26, 32) that operate along the path H of the armature device 100. In this respect, they represent working gaps. The radial projection of the working gaps 121, 122 on the fixed radius, e.g. the radius of the inner surface of the armature cylinder sleeves 26, 22, 32, produces a working gap plane whose size depends on this radius and the corresponding gap widths S_1, S_2. With the given currently prevailing gap width S_1, S_2 of a working gap produced by a movement of the armature device 100, the size of the working gap is decisive for the magnetic force active between the yoke element ad the armature element. The gap 109 extends with a width T vertical to the working direction (direction of stroke 123) of the armature device 100. No magnetic forces that perform work

occur. Thus, these gaps 108 represent undesired "magnetic resistances" and are referred to as so-called "parasitic gaps". A minimization of the width T of these parasitic gaps 109 is desirable but limits are set by unavoidable production engineering tolerances.

At page 17, the third full paragraph is amended to read as follows:

In this respect, the force curve of the overall force F_M can be altered over the stroke path H of the armature device 100 through the choice of working gap widths S_1, S_2. Thus, it is easy to influence, in the manner described below, the spray characteristics, the pressure characteristic, the maximum injection volume flow or similar characteristics of the device 1, for example. It is of course within the scope of the invention to make the working gap widths S_1 and S_2 identical or, alternatively, of different sizes. Moreover, the armature elements 102, 103 can be arranged at various positions adjustable in an axial direction on the armature carrier element 101.

At page 17, the fifth full paragraph is amended to read as follows:

The mode of operation of the device to convey and/or spray free-flowing media, in particular fluids, in accordance with the invention will be explained in more detail below.

At page 19, the first full paragraph is amended to read as follows:

Depending on the ON duration of the coil current (the duration of energization of the coil 47), the pressure impact conveying or spraying of the medium is followed by a displacement conveying or spraying of the medium when the armature device 100, in particular the armature carrier element 101, is moved further in the direction of delivery 5 in the pressure space 88.

At page 19, the third full paragraph is amended to read as follows:

In accordance with further embodiments, the flow paths for the medium to be conveyed or sprayed, and the valve devices, are adjusted for conveying or spraying free-flowing media, e.g. dusty, granular, granulated or powdered media or fluids mixed with solids, e.g. sludges.

See the attached Appendix for the changes made to effect the above paragraph.

IN THE CLAIMS:

Claims 1-41 are deleted in their entirety, without prejudice.

Claims 42-107 are added and read as follows:

42. (New) A device to deliver a free-flowing medium, comprising:

a drive housing defining a delivery direction of the free-flowing medium;

a magnet coil disposed within the drive housing, the magnetic coil being constructed to generate a magnetic flux in an energized state;

an axially movable armature device disposed within the magnet coil, the axially movable armature device comprising at least first and second armature elements, the armature elements being disposed a predetermined distance from one another in the delivery direction, the armature elements defining first and second faces; and

an armature cylinder disposed within the magnet coil adjacent to the armature elements, the armature cylinder comprising at least first and second elements constructed to interrupt the magnetic flux,

wherein the first and second flux-interrupting elements are disposed adjacent to first and second lands, and

wherein the first and second lands are disposed first and second predetermined distances from the first and second faces of the armature elements to establish first and second gaps that interrupt magnetic flux, thereby establishing the magnetic flux at least within the armature cylinder, the armature elements, and the drive housing.

43. (New) The device of claim 42, wherein the armature cylinder comprises, in the delivery direction:

a first armature cylinder sleeve;

the first flux-interrupting element;

a second armature cylinder sleeve;

the second flux-interrupting element; and

a third armature cylinder sleeve,

wherein the first and second flux-interrupting elements are annular.

44. (New) The device of claim 42, wherein:

the first and second predetermined distances establishing the first and second gaps are identical.

45. (New) The device of claim 42, wherein:

the first and second predetermined distances establishing the first and second gaps differ from one another.

46. (New) The device of claim 42, wherein:

at least one of the first and second predetermined distances establishing the first and second gaps is zero when the magnet coil is in an de-energized state.

47. (New) The device of claim 42, wherein:

the first and second armature elements are affixed to an armature carrier element.

48. (New) The device of claim 47, wherein:

the first and second armature elements are immovably affixed to the armature carrier element at the predetermined distance from one another.

49. (New) The device of claim 47, wherein:

the first and second armature elements are movably affixed to the armature carrier element so that the predetermined distance therebetween is adjustable.

50. (New) The device of claim 47, wherein:

the first and second armature elements are ring-shaped and define central bores therein through which the armature carrier element is disposed, and

the first and second armature elements extend first and second predetermined extension distances in the delivery direction such that the first and second armature elements, in a de-energized state of the magnet coil, are at least partially coextensive with portions of the armature cylinder and the first and second elements constructed to interrupt the magnetic flux, thereby permitting the magnetic flux to be conducted from the armature cylinder to the first and second armature elements.

51. (New) The device of claim 50, wherein the first and second armature elements are cylindrical.

52. (New) The device of claim 50, wherein:

the first and second predetermined distances establishing the first and second gaps are at least one half of the first and second predetermined extension distances.

53. (New) The device of claim 43, wherein:

the first and second armature elements have first and second outer diameters,

the first, second and third armature cylinder sleeves have first, second and third inner diameters, and

the first and second outer diameters are less than the first, second and third inner diameters to form a radial gap between the first and second armature elements and the first, second, and third, armature cylinder sleeves.

54. (New) The device of claim 53, wherein:

the first and second armature element outer diameters are equal to one another, and

the first, second, and third armature cylinder sleeve inner diameters are equal to one another.

55. (New) The device of claim 43, wherein:

the first and second armature elements and the first, second, and third armature cylinder sleeves are magnetizable.

56. (New) The device of claim 55, wherein the first and second armature elements are made of a magnetically-conductive material.

57. (New) The device of claim 42, wherein:

the first and second armature elements each define at least one overflow bore therethrough.

58. (New) The device of claim 57, wherein:

the overflow bores are disposed parallel to the central bores of the first and second armature elements.

59. (New) The device of claim 42, wherein:

the first and second elements constructed to interrupt the magnetic flux are made of a material capable of conducting no more than a fraction of the magnetic flux.

60. (New) The device of claim 42, wherein:

the first and second elements constructed to interrupt the magnetic flux are made of a material incapable of conducting the magnetic flux.

61. (New) The device of claim 42, wherein:

the first and second elements constructed to interrupt the magnetic flux are made of a non-magnetizable material.

62. (New) The device of claim 42, wherein:

the magnet coil comprises a plurality of magnet coils disposed axially adjacent to one another.

63. (New) The device of claim 62, wherein:

the plurality of magnet coils comprises a number corresponding to an armature-yoke arrangement.

64. (New) The device of claim 62, wherein:

each of the plurality of magnet coils is separately energizable.

65. (New) The device of claim 62, wherein:

the plurality of magnet coils are disposed from one another by a predetermined magnet distance equal to the predetermined distance between the first and second armature elements.

66. (New) The device of claim 62, wherein:

the armature cylinder comprises at least first, second, and third armature cylinder sleeves disposed an armature cylinder distance from one another, and

the plurality of magnet coils are disposed from one another by a predetermined magnet distance equal to the armature cylinder distance.

67. (New) The device of claim 66, wherein:

the armature cylinder distance and the predetermined distance between the first and second armature elements are equal.

68. (New) The device of claim of claim 43, wherein:

the first armature cylinder sleeve functions as a magnetically-conductive element, and

the second and third armature cylinder sleeves function as magnetically-conductive yoke elements.

69. (New) The device of claim 42, wherein:

the drive housing, the armature cylinder, the armature device, and the magnet coil are rotationally symmetric about a common longitudinal axis.

70. (New) The device of claim 42, wherein:

a first end of the armature cylinder defines a bearing bore, and

a second end of the armature cylinder is disk-shaped and defines a central, stepped bore, thereby defining an armature space therein.

71. (New) The device of claim 70, further comprising:

a guide cylinder defining a central bore therein, the guide cylinder being disposed within the stepped bore at the second end of the armature cylinder so that the guide cylinder is disposed within the armature space.

72. (New) The device of claim 71, further comprising:

an armature carrier element to which the first and second armature elements are affixed;

a guide piece disposed within the drive housing adjacent to the first armature element, the guide piece defining a central bore therein,

wherein a first end of the armature carrier element is disposed in the central bore of the guide cylinder, and

wherein a second end of the armature carrier is disposed within the central bore of the guide piece; and

a pressure spring disposed between the second end of the armature cylinder and the armature carrier element, thereby biasing the armature carrier element against the guide piece when the magnetic coil is in a de-energized state.

73. (New) The device of claim 72, wherein:

the pressure spring is disposed between the second end of the armature cylinder and the second armature element affixed to the armature carrier element.

74. (New) The device of claim 72, wherein:

the pressure spring is disposed between the guide cylinder and the second armature element affixed to the armature carrier element.

75. (New) The device of claim 47, wherein:

the armature carrier element is a cylindrical tube defining a central bore therein, and

a first end of the armature carrier element forms a valve seat.

76. (New) The device of claim 75, further comprising:

a valve body disposed a predetermined valve distance, in the delivery direction, from the valve seat of the armature carrier element.

77. (New) The device of claim 42, further comprising:

a coil frame comprising

a carrier base tube wall having a cylindrical shape, and

first and second boundary piston lands extending radially from first and second ends of the carrier base tube wall,

wherein the carrier base tube wall is disposed adjacent to the armature cylinder.

78. (New) The device of claim 42, further comprising:

a coil frame comprising

a carrier base tube wall having a cylindrical shape, and

first and second boundary piston lands extending radially from first and second ends of the carrier base tube wall,

wherein the carrier base tube wall forms at least a part of the armature cylinder.

79. (New) The device of claim 42, further comprising:

a coil frame comprising

a carrier base tube wall having a cylindrical shape, and

first and second boundary piston lands extending radially from first and second ends of the carrier base tube wall,

wherein the carrier base tube wall comprises the armature cylinder.

80. (New) The device of claim 42, wherein the drive housing comprises:

a cylindrical outer jacket wall, and

a base wall closing one end of the cylindrical outer jacket wall opposite to the delivery direction,

wherein the cylindrical outer jacket wall and the base wall define a drive housing inner space, and

wherein the base wall is stepped to define a base cavity adjacent to the drive housing inner space.

81. (New) The device of claim 80, further comprising:

a guide piece disposed within the drive housing adjacent to the first armature element and the base cavity.

82. (New) The device of claim 81, wherein:

the base cavity is disposed between the guide piece and the base wall.

83. (New) The device of claim 42, wherein:

the armature cylinder comprises a base part extending radially outward therefrom at a distance from the base wall of the drive housing, and

the base part forms the bottom of the drive housing.

84. (New) The device of claim 83, wherein:

the base part comprises a nozzle retaining cylinder protruding therefrom in the delivery direction.

85. (New) The device of claim 84, wherein:

the base part defines a bore therethrough,

a cylinder guide extends from the bore through the base part to the first and second armature elements,

a first end of the cylinder guide is disposed within a blind hole bore within the bore,

the blind hole bore is delimited by a nozzle retaining cylinder, and

the blind hole bore has a larger cross-sectional area than that of the bore disposed through the base part.

86. (New) The device of claim 85, further comprising:

at least a pressure space end element,

a carrier element for a stationary pressure valve, and

a spray nozzle element with a spring loaded injector needle,

wherein the pressure space end element, the carrier element, and the spray nozzle are disposed in the blind hole bore.

87. (New) The device of claim 86, wherein:

the pressure space end element, the carrier element, and the spray nozzle are disposed axially adjacent one another in the delivery direction.

88. (New) The device of claim 86, wherein:

the pressure space end element defines a pressure space bore therethrough, coaxial to the bore through the base part,

in the delivery direction, the pressure space end element defines a tapered end to the pressure space bore, and

the tapered end tapers in the delivery direction to an overflow bore to define an annular face.

89. (New) The device of claim 88, wherein:

the pressure space bore and the bore through the base part define a pressure space adjacent to the overflow bore, and

the overflow bore comprises a plurality of ribs disposed radially around its circumference, protruding into the pressure space, and defining a support for a valve body.

90. (New) The device of claim 89, further comprising:

a pressure spring disposed in the pressure space with a first end disposed against the pressure space end element and a second end disposed against the valve body to press the valve body against the plurality of ribs when in a de-energized state.

91. (New) The device of claim 86, wherein:

the carrier element is disposed axially adjacent to the pressure space end element,

the carrier element includes a multiple stepped bore therethrough that initially tapers in the delivery direction and then enlarges to form a pressure retention chamber, and

a stationary pressure valve is positioned within the pressure retention chamber.

92. (New) The device of claim 91, wherein:

the stationary pressure valve maintains a predetermined minimum pressure in the pressure retention chamber, opening when the a pressure higher than the predetermined minimum pressure is exceeded.

93. (New) The device of claim 83, further comprising:

a feed device disposed within a feed bore,

wherein the feed bore is disposed radially through the base part from an outside wall to a pressure space within the base part, and

wherein a feed direction is defined from the outside wall to the pressure space within the base part.

94. (New) The device of claim 93, wherein the feed device comprises:

a feed nipple disposed within the feed bore adjacent the outside wall of the base part; and

a return valve element disposed radially inward from the feed nipple.

95. (New) The device of claim 94, wherein:

the return valve element prevents the free-flowing medium from flowing opposite to the feed direction.

96. (New) The device of claim 94, wherein:

the feed bore is fluidly connected to an armature space within the drive housing via a first flood bore, which extends from the feed bore at a position radially outside of the return valve element to the armature space.

97. (New) The device of claim 96, wherein:

the feed bore is connected to the armature space via the first flood bore and a cross bore that extends from the feed bore at the position radially outside of the valve element to one end of the first flood bore.

98. (New) The device of claim 96, further comprising:

a drain nipple disposed within a drain bore,

wherein the drain bore extends from the outside wall of the base part to a location adjacent to the pressure space.

99. (New) The device of claim 98, wherein:

the drain bore is fluidly connected to the armature space via a second flood bore.

100. (New) The device of claim 98, wherein:

the drain nipple is disposed at a position radially opposite to that of the feed nipple.

101. (New) The device of claim 98, wherein:

the feed nipple, the first flood bore, the armature space, the second flood bore, and the drain nipple form a flow path that facilitates rinsing of the armature space with free-flowing medium.

102. (New) The device of claim 98, wherein:

the feed nipple, the return valve, the ribs protruding into the pressure space, the armature space, the first and second flood bores, and the drain nipple form a flow path that facilitates rinsing of the pressure space with free-flowing medium when the armature carrier element is disposed a distance from the valve body.

103. (New) The device of claim 98, wherein:

the pressure space is hydraulically separated from the armature space when the armature carrier element touches the valve body while moving in the delivery direction, thereby imparting kinetic energy from the armature element to the free-flowing medium in the pressure space in the form of a pressure impact.

104. (New) The device of claim 42, wherein:

the free-flowing medium may be one selected from a group comprising dusty, granular, granulated, powdered, fluid, fluid mixed with solids, and sludges.

105. (New) The device of claim 42, wherein:

the free-flowing medium is a fuel.

106. (New) The device of claim 47, wherein:

the armature carrier element is made of a magnetic conductor in at least one region adjacent to the first and second armature carrier elements.

107. (New) The device of claim 106, wherein:

the armature carrier element is made of stainless steel.

See the attached Appendix for the changes made to effect the above claims.

REMARKS

Prior to examination of the above-captioned application, the Applicants respectfully request entry of the amendments presented herein. After entry of this Second Preliminary Amendment, claims 42-107 will be pending.

The amendments detailed herein are presented to correct grammatical errors and to provide claims drafted in the appropriate format for the examination in the U.S. None of the amendments is occasioned by the prior art or any rejection in view of the prior art. Therefore, the presentation of claims 42-107 does not trigger the application of prosecution history estoppel thereto.

Attached is a marked-up version of the changes made to the specification and claims by the current amendment. The attached Appendix is captioned **"Version with markings to show changes made"**.

If there are any fees due in connection with the filing of this paper that are not otherwise accounted for, please charge our Deposit Account No. 03-3975 and refer to Order No. 009919/0290522.

Respectfully submitted,

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APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE ABSTRACT:

The Abstract is amended to read as follows:

The invention concerns a device to convey and/or spray free-flowing media, in particular fluids, which works in accordance with the energy storage principle and is designed as an electromagnetically-powered reciprocating pump with at least one armature device [100] as a drive element, whereby the armature device [100 displays] includes at least two armature elements [102, 103] and the armature elements [102, 103] are assigned magnetically corresponding yoke elements [26, 32].

IN THE SPECIFICATION:

At page 1, before the first line of the specification and after the Title, the paragraph added by the Preliminary Amendment dated February 11, 2002, is deleted and replaced with the following paragraph and heading:

[This application is the National Phase of International Application PCT/EP00/07210 filed July 26, 2000 which designated the U.S. and that International Application was not published under PCT Article 21(2) in English.]

This is a National Phase entry from PCT Patent Application Serial No. PCT/EP00/07210, filed on July 26, 2000, which designated the United States. The PCT Patent Application was not published under PCT Article 21(2) in English. This application relies for priority on German Patent Application No. 199 37 988.2, filed on August 11, 1999. Both applications are incorporated herein by reference.

Field of the Invention

At page 1, before the second full paragraph beginning on line 7, insert the following heading:

Description of the Related Art

At page 2, before the third full paragraph beginning on line 10, insert the following heading:

Summary of the Invention

At page 2, the third full paragraph is amended as follows:

This results in increasing demands on the injection systems of these internal combustion engines with respect to the flow rates per working cycle and with respect to the volume flow ([-] i.e., fluid flow rate per unit of time).

At page 2, the fourth full paragraph is amended as follows:

This increased flow rate per working cycle and the increased volume flow can be achieved, for example, by enlarging the electromagnets, though these then also have a higher electrical power consumption. But this entails additional costs not only for the larger elements but also, and above all, for generators [that are more powerful] and control circuits for the electromagnets <u>that are more powerful</u>.

At page 3, the first full paragraph is amended as follows:

[A device with the features of claim 1 solves this task. Advantageous embodiments are identified in the sub-claims.] <u>It is, therefore, one aspect of the invention to provide a device that resolves the deficiencies in the art.</u>

At page 4, the third full paragraph is amended as follows:

[In a] <u>A</u> preferred variant <u>of</u> the armature device is designed as a two-armature element device and is surrounded by an armature cylinder with two corresponding yoke elements, e.g., armature cylinder sleeves.

At page 4, the fourth full paragraph is amended as follows:

[In a] <u>A</u> particularly preferred variant <u>of</u> the device, in accordance with the invention, works according to the solid body energy storage principle.

At pages 4-5, the carry-over paragraph is amended as follows:

With a device to convey and/or spray free-flowing media, in particular fluids, in accordance with the invention, it is advantageous that, with a given electrical energy supply, the static magnetic force on the armature device is much higher than the state-of-the-art and, thus, the work performed by the armature device along its stroke path is much greater. In this respect,

the energy transmitted by the armature device to the medium to be conveyed or sprayed and, thus, the efficiency of the device in accordance with the invention, is significantly increased. A device in accordance with the invention [re-quires] requires only a small structural space on account of the axially serial arrangement of the armature elements in a magnetic serial connection.

At page 5, before the second full paragraph, the following heading is added:

Brief Description of the Drawings

At page 5, the description of the drawings is amended to read:

Fig. 1 is a longitudinal section through a device in accordance with the invention to convey and/or spray free-flowing media, in particular fluids;

Fig. 2 is a detailed view of the longitudinal section of [a] the device [in accordance with] illustrated in Fig. 1; and

Fig. 3 is a diagrammatic view of the flux distribution characteristics of the magnetic lines of force of [a] the device [in accordance with the invention according to] illustrated in Fig. 1.

At page 5, the following heading is inserted before the last full paragraph:

Description of Preferred Embodiment(s) of the Invention

At page 6, the first full paragraph is amended to read as follows:

The drive housing 2 has a thin-walled, cylinder jacket-shaped outside wall 6 and a thin-walled base wall 7 that closes one end of the drive housing 2 so that a drive housing inner space 8 is limited. The base wall 7 has two steps radial to the central longitudinal axis 4. The base wall 7 has a first annular face wall 9 running [radial] radially from the outside to the

inside, a first annular stepped wall 10 running [coaxial] coaxially to the outside wall 6, a second annular face wall 11 running opposite to the direction of delivery 5 and set back from the first annular face wall 9, a second annular face wall 12, and a rear final wall 13 axial to the direction of delivery 5. The outside wall 6 [displays] includes a recess 14 near the first annular face wall 9 containing a connecting device 15 with contact elements 16 to connect the device 1 to an electricity supply. In the front, open end of the drive housing 2, in the direction of delivery 5, there is a thread 17 on the inner side of the outside wall.

At page 6, the second full paragraph is amended to read as follows:

An essentially [cylindrical] cylindrically disk-shaped guide piece 18 sits in the radial inner partial area of the inner side of the second annular face wall 11, so that a base cavity 19 is bordered by the guide piece 18, the second annular face wall 12 and the final wall 13. The guide piece 18 has a central bearing bore 20 with the central longitudinal axis 4 as the bore axis. A number of through bores 21 are arranged radially around the bearing bore 20, parallel to the bearing bore 20, which run into the base cavity 19 on the base side.

At page 6, the third full paragraph is amended to read as follows:

A first cylindrical tube-shaped armature cylinder sleeve 22 that protrudes slightly into the drive housing inner space 8 away from the base wall 7, with the central longitudinal axis 4 as a center axis, sits as a conducting element radially [positive] positioned between the guide piece 18 and the first annular stepped wall 10 and axially [positive] positioned on the guide piece 18. The first armature cylinder sleeve 22 is made of a very good magnetically conductive material and displays a face 23 on the inner space side from which a small piston land 24 protrudes axially in the direction of delivery 5.

At page 7, the second full paragraph is amended to read as follows:

Analogous to the first annular element 25, a second annular element 31, which has the same three-dimensional shape as the first annular element 25 and is also made of a magnetic nonconducting, non-magnetizable material, e.g. stainless steel, sits on the face 28 of the second armature cylinder sleeve 26 as a spacing element or means to interrupt the magnetic flux.

At page 7, the last paragraph bridging pages 7 and 8, is amended to read as follows:

The armature cylinder sleeves 22, 26, 32 and the annular elements 25, 31 form an armature cylinder 35 with the central longitudinal axis 4 as the central axis, which circumscribes an armature space 41. The armature space 41 is limited on the base wall side by the guide piece 18 and on the pump housing side by the inner ring area 40a of the face 40 of the pump housing 3.

At page 8, the fifth full paragraph is amended to read as follows:

In the space delimited by the walls, 44, 45, 46, there is a magnet coil 47 connected to the contact elements 16 of the connecting device 15.

At page 9, the first full paragraph is amended to read as follows:

The base part 50 is cylindrical disk-shaped and delimited on the base side by the face 40 and the inner area 40a of the face 40 and on the opposite side by a face 55. The base part 50 has a circumferential surface 53 whose base-side end area has a male thread 54 corresponding to the female thread 17 of the drive housing 2. The base part 50 is screwed into the drive housing 2 so far that the armature cylinder sleeves 22, 26, 32 and the annular elements 25, 31

are pressed axially against one another, and this is supported by the guide piece 18 on the second annular ring wall 11. A sealing ring 55, e.g. an O-ring, is provided to seal off the base cavity 19 and the armature space 41 from the coil space 42, which sits in a sealing channel 56 formed by a base-side face of the first armature cylinder sleeve 32, the first annular ring wall 10, the second annular ring wall 11 and an L-shaped recess in the guide piece 18.

At page 9, the second full paragraph is amended to read as follows:

The base part 50 has a simple stepped- through bore 57 with the central longitudinal axis 4 as the central axis. The stepped-through bore 57 is enlarged on the base side [as] at a location hole 57a, which ends in the armature space 41. At [and at] the other end, the stepped-through bore 57 is enlarged by a blind hole bore 58 delimited by the nozzle retaining cylinder 51. It is enlarged compared to the stepped through bore 57.

At page 9, the third full paragraph is amended to read as follows:

In the enlargement of the stepped through bore 57 on the armature space side, there is a positive and non-positive-locked guide cylinder 59 tapered in two steps. The guide cylinder 59 [that] protrudes into the armature space 41 on a level with the inner area 40a forming an annular face 60 and an annular projection 61.

At page 9, the last paragraph bridging pages 9 and 10 is amended as follows:

The guide cylinder 59 displays a stepped through bore 62 corresponding to the bearing bore 20 that has the central longitudinal axis 4 as a central axis. In [in] other words, the guide cylinder 59 is axially aligned [to] with the bearing bore 20 of the guide piece 18. The through bore 62 is enlarged to the diameter of the through bore 57 at its armature space 41 end. Around the inner circumference of the enlarged area of the through bore 62 there are a

number of spaced positioning ribs 63 for a valve body 64 that point radially inwards. The valve body 64 rests in the through bore 57 with play, so that the areas in front of and behind the valve body 64 are hydraulically connected.

At page 10, the first full paragraph is amended to read as follows:

A multiple, tapering, feed bore 65 for the medium to be conveyed or sprayed leads radially from the outer surface 53 of the pump housing 3 and ends in the through bore 57. There is a feed device 66 in the feed bore 65 consisting of a hollow drilled feed nipple 67 and a return valve element 69 positioned radially inwards after this in the feed direction 68 that prevents the medium from flowing opposite to the feed direction 68.

At page 11, the first full paragraph is amended to read as follows:

The pressure space bore 85 and the through bore 87 delimit a pressure space 88 that is sealed on the drive side by [a] the spherical valve body 64 and ends on the nozzle side in the overflow bore 86.

At page 12, the first full paragraph is amended to read as follows:

The device 1 has a standard armature device 100 as a drive element that [consists of] comprises an armature carrier element 101, e.g. a delivery plunger tube, and a first armature element 102 on the base side. The standard armature device 100 also comprises [and] a second, identical armature element 103 on the pressure space side, positioned at a distance D (Fig. 2) from the first armature element 102.

At page 12, the third full paragraph is amended to read as follows:

The armature carrier element 101 is designed, e.g. as a delivery plunger tube, which is essentially a hollow cylindrical, long stretched-out body that can be moved axially. The armature carrier element 101 [and] is [positive] locked positively in a radial direction with its base end 104 in the bearing bore 20 of the guide piece 18, passing through the armature space 41, and with its pressure space-side end 105 in the bearing bore 62 of the guide cylinder 59. In the starting position, the end 104 protrudes slightly into the base cavity 19, whereby the end 105 is roughly flush with the pressure space-side end of the bearing bore 62 of the guide cylinder 59. The end 105 [and] is located at a slight distance from the valve body 64, which rests on the ribs 63. The armature carrier element 101 has an axial through bore 106 the ends of which are conically enlarged in the manner of a phase. The chamfer of the armature carrier element 101 on the pressure space side forms a valve seat for the valve body 64 so that the armature carrier element 101 and the valve body 64 form a valve with which the armature space 41 can be hydraulically separated from the pressure space 88.

At page 12, the last paragraph bridging pages 12 and 13 is amended to read as follows:

Referring to Fig. 2, the [The] armature elements 102, 103 are located in the armature space and each are essentially, cylindrically [cylindrical] ring disk-shaped. Each [and each] has a central bore 107 and 108, which have the central longitudinal axis 4 as their central axis. The armature elements 102, 103 sit firmly with the bore 107, 108 [firmly] on the armature carrier element 101 and have an outer diameter that is slightly smaller than the inner diameter of the armature cylinder sleeves 22, 26, 32, thus forming a radial play gap 109 of the width T. The armature elements 102, 103 thus rest in the armature space 41 with a radial play to the armature cylinder 35 and can be moved in an axial direction. The armature elements 102,

103 are made of a lightweight, magnetizable material and each has at least one overflow bore 110 parallel to the central bores 107, 108.

At page 13, the first full paragraph is amended to read as follows:

The armature element 102 has a face 110a on the base side and face 111 on the pressure space side. The armature element 102 also has [as well as] a circumferential face 112. The face 111 and the circumferential face 112 form a circumferential edge 113 ([cf.] see, e.g., Fig. 2). The armature element 103 accordingly has a face 114 on the base side and a face 115 on the pressure space side. It also has [as well as] a circumferential face 116. The face 115 and the circumferential face 116 form a circumferential edge 117.

At page 13, the second full paragraph is amended to read as follows:

As described above, the face 110 of the first armature element 102 rests on the guide piece 18 on the armature space side in the starting position. The axial longitudinal extension of the armature element 102 is [conceived] constructed so that it covers the part of the armature cylinder sleeve 22 that delimits the armature space 41 in the axial direction and so that there is a first axial gap 121 with a gap width S_1 between its circumferential edge 113 and the piston land 29 of the second armature cylinder sleeve 26.

At page 14, the first full paragraph is amended to read as follows:

The axial overlap of the armature elements 102, 103 (and the corresponding adjacent armature cylinder sleeves 22 and 26 in the starting position and the respective adjacent annular elements 25 and 31 in the starting position) has been chosen so that the magnetic flux is optimized.

At page 14, the last paragraph bridging pages 14 and 15 is amended to read as follows:

If the coil 47 is supplied with current in the starting position as shown in Fig. 2, magnetic lines of force 130 form toroidally around the coil body (Fig. 3). Depending on the polarity, they enter the first armature cylinder sleeve 22, e.g. from the base side, the armature element 102 thus bridging the radial gap 18 (the parasitic gap between the armature cylinder sleeve 22 and the first armature element 102). The magnetic lines of force 130 leave the armature element 102 to a large extent in the area of the narrowest point between the armature element 102 and the second armature cylinder sleeve 26 (yoke element)[,]. The magnetic lines of force 130 run roughly axially in the second armature cylinder sleeve 26 up to the overlap area of the second armature element 103 and the second armature cylinder sleeve 26[,]. The magnetic lines of force 130 enter the second armature element 103 by bridging the gap 108 (parasitic gap) between the armature cylinder sleeve 26 and the second armature element 103[,]. The magnetic lines of face 130 leave the second armature element 103 in a manner analogous to the first armature element 102 to a large extent at the narrowest point between the second armature element 103 and the third armature cylinder sleeve 32[and]. Finally, the magnetic lines of force 130 enter the third armature cylinder sleeve 32 (see Fig. 3).

At page 15, the first full paragraph is amended to read as follows:

As a result of this, the areas of the armature elements 102 and 103 (faces 111 and 115) and the armature cylinder sleeves 26 and 32 (piston lands 29 and 34) opposite the abovementioned narrow points are magnetized with opposite poles so that static magnetic forces F_{M1} and F_{M2} work on the armature element 102 and the armature element 103. The armature elements 102, 103 thus represent armatures (in the sense of the abovementioned

definition) and the armature cylinder [sleeves] sleeve 26, 32 yoke elements (in the sense of the abovementioned definition).

At page 15, the second full paragraph is amended to read as follows:

The total static magnetic force $F_M = F_{M1} + F_{M2}$ that works on the armature device 100 is much higher with the same input of electrical energy, due to the abovementioned magnetic series connection of the armature elements 102, 103 and the corresponding yoke elements 25, 32[,] than a resulting magnetic force with an armature device that has a single armature element only. Thus, the output of the armature device 100 over a certain distance H along a direction of stroke 123 is correspondingly higher. In this respect, this leads to a better use of the magnetic energy generated by the coil 47 by means of a pre-defined input energy. Thus, the efficiency of a drive device of this type, with a multiple armature device 100 with armature elements 102 and 103 yoke elements corresponding to the armature elements 102 and 103, and thus the overall efficiency of a device 1 in accordance with the invention, is significantly improved.

At page 16, the first full paragraph is amended to read as follows:

The gaps 121 and 122 extend in the working direction (direction of stroke 123) of the armature device 100. The widths S_1 and S_2 of these gaps determine the amount of the static magnetic forces that momentarily occur between the armature elements 102, 103 and the yoke elements (armature cylinder sleeves 26, 32) that operate along the path H of the armature device 100. In this respect, they represent working gaps. The radial projection of the working gaps 121, 122 on the fixed radius, e.g. the radius of the inner surface of the armature cylinder sleeves 26, 22, 32, produces a working gap plane whose size depends on this radius and the corresponding gap widths S_1, S_2. With [a give] the given currently

prevailing gap width S_1, S_2 of a working gap produced by a movement of the armature device 100, the size of the working gap is decisive for the magnetic force active between the yoke element ad the armature element. The gap 109 [extend] extends with a width T vertical to the working direction (direction of stroke 123) of the armature device 100. No magnetic forces that perform work occur. Thus, these gaps 108 represent undesired "magnetic resistances" and are referred to as so-called "parasitic gaps". A minimization of the width T of these parasitic gaps 109 is desirable but limits are set by unavoidable production engineering tolerances.

At page 17, the third full paragraph is amended to read as follows:

In this respect, the force curve of the overall force F_M can be altered over the stroke path H of the armature device 100 through the choice of working gap widths S_1, S_2. Thus, [and] it is [thus] easy to influence, in the manner described below, [e.g.] the spray characteristics, the pressure characteristic, the maximum injection volume flow or similar characteristics of the device 1, for example. It is of course within the scope of the invention to make the working gap widths S_1 and S_2 identical or, alternatively, of different sizes. Moreover, the armature elements 102, 103 can be arranged at various positions adjustable in an axial direction on the armature carrier element 101.

At page 17, the fifth full paragraph is amended to read as follows:

The mode of operation of the device to convey and/or spray free-flowing media, in particular fluids, in accordance with the invention will be explained in more detail [in the following:] below.

At page 19, the first full paragraph is amended to read as follows:

Depending on the ON duration of the coil current <u>(the duration of energization of the coil 47)</u>, the pressure impact conveying or spraying of the medium is followed by a displacement conveying or spraying of the medium when the armature device 100, in particular the armature carrier element 101, is moved further in the direction of delivery 5 in the pressure space 88.

At page 19, the third full paragraph is amended to read as follows:

In accordance with further embodiments, the flow paths for the medium to be conveyed or sprayed, and the valve devices, are adjusted for conveying or spraying free-flowing media, e.g. dusty, granular, granulated or powdered media or fluids mixed with solids, e.g. sludges.

<u>IN THE CLAIMS:</u>

Claims 1-41 are deleted in their entirety.

New claims 42-107 are added.

END OF APPENDIX

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION OF

Inventor(s): HELLMICH et al.

Filed: Herewith

Title: DEVICE FOR DELIVERING AND/OR SPRAYING FLOWABLE MEDIA, ESPECIALLY FLUIDS

February 11, 2002

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents
Washington, D.C. 20231

Sir:

Please amend this application as follows:

IN THE SPECIFICATION:

At the top of the first page, just under the title, insert

☒ --This application is the National Phase of International Application PCT/EP00/07210 filed July 26, 2000 which designated the U.S. and that International Application ☐ was ☒ was not published under PCT Article 21(2) in English.--

See the attached Appendix for the changes made to effect the above paragraph.

Respectfully submitted,

PILLSBURY WINTHROP LLP
Intellectual Property Group

By: ____________________

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PTB/jck
Attachment:
Appendix

1600 Tysons Boulevard
McLean, VA 22102
(703) 905-2000

APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

The specification is changed as follows:

☒ --This application is the National Phase of International Application PCT/EP00/07210 filed July 26, 2000 which designated the U.S. and that International Application ☐ was ☒ was not published under PCT Article 21(2) in English.--

PTO/PCT Rec'd 16 AUG 2002 10/049243

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M 4748/XI/nk

Device to convey and/or spray free-flowing media, in particular fluids

The invention concerns a device to convey and/or spray free-flowing media, in particular fluids, which works in accordance with the energy storage principle and is designed as an electro-magnetically powered reciprocating pump.

A device of this kind is familiar for example from WO 96/34196. These injection devices work according to the solid body energy storage principle and have an armature space enclosed by an armature cylinder in which an armature device, acting as the drive device, is borne in such a manner that its can move axially. The armature cylinder is enclosed by a magnet coil which is electrically controlled and which generates the magnetic field necessary to drive the armature device. The armature cylinder encloses two axially successive armature cylinder sleeves between which there is an annular element made of a magnetic non-conductor. The armature device has an axially movable delivery plunger tube and an armature element fastened on this. The armature element sits in the armature cylinder with radial play. The clearance represents a magnetic resistance that weakens the magnetic flux and is referred to as a so-called parasitic gap.

The armature device absorbs kinetic energy in operation during an almost resistanceless acceleration phase, whereby the resistanceless acceleration phase is generated by a valve that closes a pressure space so that the fluid contained in the pressure space that is to be sprayed experiences a pressure impact that spreads through the pressure space in the form of a pressure wave The pressure wave effects an opening of a spring-loaded injection nozzle element that closes the other end of the pressure space so that the fluid in the pressure space is sprayed out.

After the injection nozzle element has opened and the fluid has been sprayed out due to the pressure impact, the armature device, and in particular its delivery plunger tube, is moved further in the pressure space thus leading to a continuation of the spraying process in the form of a displacement spraying. The return stroke of the armature device is effected by a pressure spring.

Such fluid injection devices have proven their worth, for example as fuel injection devices for internal combustion engines, in particular for two-stroke internal combustion engines.

The development trends in the field of modern internal combustion engines, in particular modern two-stroke internal combustion engines for recreational sports equipment such as personal water craft or snowmobiles, are towards larger cylinder piston capacities with constant or even higher nominal speeds and a simultaneous reduction of the number of cylinders in the internal combustion engine for cost and weight reasons.

This results in increasing demands on the injection systems of these internal combustion engines with respect to the flow rates per working cycle and with respect to the volume flow (- fluid flow rate per unit of time).

This increased flow rate per working cycle and the increased volume flow can be achieved for example by enlarging the electromagnets, though these then also have a higher electrical power consumption. But this entails additional costs not only for the larger elements but also and above all for generators that are more powerful and control circuits for the electromagnets.

The task of the invention is to produce a device to convey and/or spray free-flowing media, in particular fluids, that guarantees a higher flow rate per working cycle and a higher volume flow of the sprayed or conveyed fluid at a certain or given electrical energy

supply and in particular a certain or given structural size, in other words is improved with respect to the efficiency.

A device with the features of claim 1 solves this task. Advantageous embodiments are identified in the sub-claims.

The terms "armature" and "yoke" will be used in the following to define the two elements that are moveable in relation to each other and between which a magnetic force is effective, whereby the "yoke" is the stationary of the two moving elements and the "armature" refers to the element that moves due to the magnetic force relative to the "yoke".

The working gap plane is an imaginary plane resulting from a radial projection of an axial gap (working gaps) between an "armature" and a corresponding "yoke" on a pre-defined diameter.

A "conducting element" in the following is understood to be an element that serves the specific transmission or guidance of the magnetic flux.

In accordance with the invention, a device to convey and/or spray free-flowing media, in particular fluids is planned that works in accordance with the energy storage principle and is designed as an electromagnetically powered reciprocating pump with at least one armature device as a drive element and where the armature device has at least two armature elements and the armature elements are assigned to magnetically corresponding yoke elements.

Within the scope of the invention, the effect is exploited whereby an enlargement of the working gap plane between one armature and its magnetically corresponding yoke means that a greater amount of energy can be transmitted from the magnetic field provided by a

coil to the armature device.

In accordance with the invention, an enlargement of the working gap plane is achieved by a very simple method, whereby a magnetic series connection of at least two armature elements together with their respective corresponding yoke elements is planned. Accordingly, an armature device is to be provided, for example, that bears a multiple of, i.e. at least two, axially spaced armature elements on an armature carrier, e.g. a delivery plunger tube.

Two stationary yoke elements are provided each of which correspond magnetically to the armature elements of the armature devices and which form a magnetic antipole for the armature elements. For example, an armature cylinder surrounding the armature device has corresponding armature cylinder sleeves as yoke elements which are separated from one another by magnetically nonconducting annular elements.

In a preferred variant the armature device is designed as a two-armature element device and is surrounded by an armature cylinder with two corresponding yoke elements, e.g. armature cylinder sleeves.

In a particularly preferred variant the device in accordance with the invention works according to the solid body energy storage principle.

With a device to convey and/or spray free-flowing media, in particular fluids, in accordance with the invention, it is advantageous that with a given electrical energy supply the static magnetic force on the armature device is much higher than the state-of-the-art and thus the work performed by the armature device along its stroke path is much greater. In this respect, the energy transmitted by the armature device to the medium to be conveyed or sprayed and thus the efficiency of the device in accordance with the invention is significantly increased. A device in accordance

with the invention re-quires only a small structural space on account of the axially serial arrangement of the armature elements in a magnetic serial connection.

The increased energy input in the medium to be conveyed or sprayed can be used depending on the geometric design of the pump device in the form of a higher flow rate per working cycle or a higher volume flow and/or a higher pressure in the medium to be conveyed or sprayed. This can be pre-determined, for example through the choice of a certain diameter of the pump equipment that pumps the media, e.g. the delivery plunger tube.

The invention will be exemplarily described in detail in the following on the basis of the drawings. These show:

Fig. 1 a longitudinal section through a device in accordance with the invention to convey and/or spray free-flowing media, in particular fluids;

Fig. 2 a detailed view of the longitudinal section of a device in accordance with Fig. 1;

Fig. 3 a diagrammatic view of the flux distribution characteristic of the magnetic lines of force of a device in accordance with the invention according to Fig. 1.

The preferred variant of the device 1 in accordance with the invention shown works in accordance with the solid body energy storage principle and shows a pot-shaped drive housing 2 and a pump housing 3 that closes an open end of the pot-shaped drive housing 2. The drive housing 2 and the pump housing 3 are essentially rotationally symmetrical bodies and have a common central longitudinal axis 4. The pump housing 3 is arranged upstream from the drive housing 2 in a direction of delivery 5 of the medium to be conveyed or sprayed.

The drive housing 2 has a thin-walled, cylinder jacket-shaped outside wall 6 and a thin-walled base wall 7 that closes one end of the drive housing 2 so that a drive housing inner space 8 is limited. The base wall 7 has two steps radial to the central longitudinal axis 4. The base wall 7 has a first annular face wall 9 running radial from the outside to the inside, a first annular stepped wall 10 running coaxial to the outside wall 6, a second annular face wall 11 running opposite to the direction of delivery 5 and set back from the first annular face wall 9, a second annular face wall 12 and a rear final wall 13 axial to the direction of delivery 5. The outside wall 6 displays a recess 14 near the first annular face wall 9 containing a connecting device 15 with contact elements 16 to connect the device 1 to an electricity supply. In the front, open end of the drive housing 2 in the direction of delivery 5 there is a thread 17 on the inner side of the outside wall.

An essentially cylindrical disk-shaped guide piece 18 sits in the radial inner partial area of the inner side of the second annular face wall 11, so that a base cavity 19 is bordered by the guide piece 18, the second annular face wall 12 and the final wall 13. The guide piece 18 has a central bearing bore 20 with the central longitudinal axis 4 as the bore axis. A number of through bores 21 are arranged radially around the bearing bore 20 parallel to the bearing bore 20 which run into the base cavity 19 on the base side.

A first cylindrical tube-shaped armature cylinder sleeve 22 that protrudes slightly into the drive housing inner space 8 away from the base wall 7, with the central longitudinal axis 4 as a center axis, sits as a conducting element radially positive between the guide piece 18 and the first annular stepped wall 10 and axially positive on the guide piece 18. The first armature cylinder sleeve 22 is made of a very good magnetically conductive material and displays a face 23 on the inner space side from which a small piston land 24 protrudes axially in the direction of delivery 5.

A first cylindrical ring-shaped annular element 25 sits axially on the face 23 of the first armature cylinder sleeve 22 as a spacing element or means to interrupt the magnetic flux and is positively held radially by the piston land 24. The annular element 25 consists of a magnetic nonconductor, e.g. stainless steel. A cylindrical ring-shaped second armature cylinder sleeve 26 follows axially on the first annular element 25 as the first yoke element and bears an axially protruding piston land 29 and 30 on the inside radius of its base-side face 27 and its pump housing-side face 28.

Analogous to the first annular element 25, a second annular element 31, which has the same three-dimensional shape as the first annular element 25 and is also made of a magnetic nonconducting, non-magnetizable material, e.g. stainless steel, sits on the face 28 of the second armature cylinder sleeve 26 as spacing element or means to interrupt the magnetic flux.

A third armature cylinder sleeve 32 follows axially on the second annular element 31 as the second yoke element which has a face 33 on its base-side end and, analogous to the second armature cylinder sleeve 26, a piston land 34. This sits axially on one end of the second annular element 31 and sits as one piece on the other end in the form of a piston land on the base-side face 40 of the pump housing.

The third armature cylinder sleeve 32 encloses a radial inner ring area 40a of the base-side face 40 of the pump housing 3.

The armature cylinder sleeves 22, 26, 32 and the annular elements 25, 31 form an armature cylinder 35 with the central longitudinal axis 4 as central axis, which circumscribes an armature space 41. The armature space 41 is limited on the base wall side by the guide piece 18 and on the pump housing side by the inner ring area

40a of the face 40 of the pump housing 3.

The radial outer surfaces of the armature cylinder sleeves 22, 26, 32 and the annular elements 25, 31 are axially aligned to each other to form a cylindrical armature cylinder outer surface.

The annular elements 25, 31 have slightly thinner walls than the armature cylinder sleeves 22, 26, 32 so that their inner surfaces have a greater radial gap to the central longitudinal axis 4 compared to the axially aligned inner surfaces of the armature cylinder sleeves 22, 26, 32.

The outer surface of the armature cylinder 35 and the outer wall 6 of the drive housing 2 delimit a cylindrical ring-shaped coil space 42. A cable drum-shaped coil frame 43 with a cylindrical tube-shaped, carrier base tube wall 44, a boundary piston land 45 protruding radially from one end on the base side and a boundary piston land 46 on the pump housing side, sits in the coil space 42 surrounding the outside of the armature cylinder 35. The boundary piston lands 45, 46 protrude radially up to shortly before the outer wall 6 of the drive housing 2.

The coil frame 43 extends from the base face 40 of the pump housing 3 to shortly before the first annular face wall 9 of the drive housing 2.

In the space delimited by the walls 44, 45, 46 there is a magnet coil 47 connected to the contact elements 16 of the connecting device 15.

Pump housing 3 is essentially a rotationally symmetrical body around the central longitudinal axis 4 with a base part 50 and a nozzle-retaining cylinder 51 shaped as one piece on the base part 50 and protruding axially from this in the direction of delivery 5.

The base part 50 is cylindrical disk-shaped and delimited on the base side by the face 40 and the inner area 40a of the face 40 and on the opposite side by a face 55. The base part 50 has a circumferential surface 53 whose base-side end area has a male thread 54 corresponding to the female thread 17 of the drive housing 2. The base part 50 is screwed into the drive housing 2 so far that the armature cylinder sleeves 22, 26, 32 and the annular elements 25, 31 are pressed axially against one another and this is supported by the guide piece 18 on the second annular ring wall 11. A sealing ring 55, e.g. an O-ring, is provided to seal off the base cavity 19 and the armature space 41 from the coil space 42, which sits in a sealing channel 56 formed by a base-side face of the first armature cylinder sleeve 32, the first annular ring wall 10, the second annular ring wall 11 and an L-shaped recess in the guide piece 18.

The base part 50 has a simple stepped through bore 57 with the central longitudinal axis 4 as the central axis, enlarged on the base side as a location hole 57a which ends in the armature space 41 and at the other end by a blind hole bore 58 delimited by the nozzle retaining cylinder 51 and enlarged compared to the stepped through bore 57.

In the enlargement of the stepped through bore 57 on the armature space side there is a positive and non-positive-locked guide cylinder 59 tapered in two steps that protrudes into the armature space 41 on a level with the inner area 40a forming an annular face 60 and an annular projection 61.

The guide cylinder 59 displays a stepped through bore 62 corresponding to the bearing bore 20 that has the central longitudinal axis 4 as a central axis, in other words is axially aligned to the bearing bore 20 of the guide piece 18. The through bore 62 is enlarged to the diameter of the through bore 57 at its armature space 41 end. Around the inner circumference of the enlarged area of the through bore 62 there are a number of spaced positioning

ribs 63 for a valve body 64 that point radially inwards. The valve body rests in the through bore 57 with play, so that the areas in front of and behind the valve body are hydraulically connected.

A multiple tapering feed bore 65 for the medium to be conveyed or sprayed leads radially from the outer surface 53 of the pump housing 3 and ends in the through bore 57. There is a feed device 66 in the feed bore 65 consisting of a hollow drilled feed nipple 67 and a return valve element 69 positioned radially inwards after this in the feed direction 68 that prevents the medium from flowing opposite to the feed direction 68.

A first flood bore 70 branches diagonally from the feed bore 65 radially outside the return valve element 68 that ends in the armature space 41 and is connected to the central bore of the feed nipple 67 via a cross bore 71. Opposite to the feed bore 65 there is a radial, blind hole-shaped drain bore 72 in the pump housing 3 in which a drain nipple 73 sits as a drain device. A second flood bore 74 branches diagonally from the base of the drain bore 72 that also ends in the armature space 41.

In the blind-hole bore 58 of the nozzle retaining cylinder 51 there are, in the following order, a pressure space end piece 80, a carrier piece 81 for a stationary pressure valve 82 and a spray nozzle element 83 with a spring-loaded injector needle 84 axial to the direction of delivery 5.

The pressure space end piece 80 sits radially positive in the blind hole bore 58 and axially on its base-side bore bottom 58a and has a pressure space bore 85 coaxial to the through bore 57

that tapers in one stage in the direction of delivery 5 to an overflow bore 86 to form an annular face 87.

The pressure space bore 85 and the through bore 87 delimit a pressure space 88 that is sealed on the drive side by a spherical valve body 64 and ends on the nozzle side in the overflow bore 86.

The valve body 64 lies on the radial inner edge of the ribs 63 in its starting position, spring-loaded by a pressure spring 89, whereby one end of the pressure spring 89 rests on the valve body 64 and the other end on the annular face 87 of the guide cylinder 59.

The carrier piece 81 is placed axially against the pressure space end piece 80 and also has a multiple stepped through bore 90 that initially tapers in the direction of delivery 5 and then enlarges to form a pressure retention chamber 91 in which the stationary pressure valve 82 is located on the pressure space side. The stationary pressure valve 82 guarantees a certain minimum pressure in the medium in the pressure-retaining chamber 91 and opens in the direction of delivery 5 as soon as a pressure higher than the standard pressure prevails in the pressure space 88.

The injector nozzle element 83 is placed against the carrier piece 81 axial to the direction of delivery 5. The injector nozzle element 83 has an axial through bore 92 in which the injector needle 84 is borne so that it can move axially. The through bore 92 has a conically enlarged sealing face 93 on the nozzle end side that is sealed off by a valve disk 94 on the nozzle end side connected as one piece to a shaft of the injector needle 84. The injector needle 84 sits pre-stressed in a known manner against the direction of delivery 5 by a pressure spring 95 and a needle disk 96 in the through bore 92, whereby the tapered end of the nozzle element 83 on the pressure space side, the pressure spring 95 and a part of the injector needle shaft protrude into the nozzle side enlargement of the through bore 90 of the carrier piece 81. The enlarge-

ment of the through bore 90 on the nozzle side is connected to the through bore 92 via an overflow bore 97.

The device 1 has a standard armature device 100 as a drive element that consists of an armature carrier element 101, e.g. a delivery plunger tube, and a first armature element 102 on the base side and a second, identical armature element 103 on the pressure space side, positioned at a distance D (Fig. 2) from the first armature element 102.

There is a pressure spring 120 between the second armature element 103 and the annular face 60 of the guide cylinder 59 that presses the armature device 100 axially in the starting position against the direction of delivery 5 so that the first armature element 102 rests against the guide piece 18.

The armature carrier element 101 is designed, e.g. as a delivery plunger tube, which is essentially a hollow cylindrical, long stretched-out body that can be moved axially and is positive locked in a radial direction with its base end 104 in the bearing bore 20 of the guide piece 18, passing through the armature space 41 and with its pressure space-side end 105 in the bearing bore 62 of the guide cylinder 59. In the starting position, the end 104 protrudes slightly into the base cavity 19, whereby the end 105 is roughly flush with the pressure space-side end of the bearing bore 62 of the guide cylinder 59 and is located at a slight distance from the valve body 64, which rests on the ribs 63. The armature carrier element 101 has an axial through bore 106 the ends of which are conically enlarged in the manner of a phase. The chamfer of the armature carrier element 101 on the pressure space side forms a valve seat for the valve body 64 so that the armature carrier element 101 and the valve body 64 form a valve with which the armature space 41 can be hydraulically separated from the pressure space 88.

The armature elements 102, 103 are located in the armature space and each are essentially cylindrical ring disk-shaped and each has

a central bore 107 and 108 which have the central longitudinal axis 4 as their central axis. The armature elements 102, 103 sit with the bore 107, 108 firmly on the armature carrier element 101 and have an outer diameter that is slightly smaller than the inner diameter of the armature cylinder sleeves 22, 26, 32, thus forming a radial play gap 109 of the width T. The armature elements 102, 103 thus rest in the armature space 41 with a radial play to the armature cylinder 35 and can be moved in an axial direction. The armature elements 102, 103 are made of a lightweight, magnetizable material and each has at least one overflow bore 110 parallel to the central bores 107, 108.

The armature element 102 has a face 110a on the base side and face 111 on the pressure space side as well as a circumferential face 112. The face 111 and the circumferential face 112 form a circumferential edge 113 (cf. Fig. 2). The armature element 103 accordingly has a face 114 on the base side and a face 115 on the pressure space side as well as a circumferential face 116. The face 115 and the circumferential face 116 form a circumferential edge 117.

As described above, face 110 of the first armature element 102 rests on the guide piece 18 on the armature space side in the starting position. The axial longitudinal extension of the armature element 102 is conceived so that it covers the part of the armature cylinder sleeve 22 that delimits the armature space 41 in the axial direction and so that there is a first axial gap 121 with a gap width S_1 between its circumferential edge 113 and the piston land 29 of the second armature cylinder sleeve 26.

The second armature element 103 is positioned accordingly at the distance D from the first armature element 102 and in front of this in the direction of delivery 5, whereby it covers the inner surface of the second armature cylinder sleeve 26 roughly over the same axial length, analogous to the first armature element 102. The axial longitudinal extension of the armature element 103 is

conceived analogous to the armature element 102 so that there is a second axial gap 122 with the gap width S_2 between its circumferential edge 117 and the piston land 34 of the third armature cylinder sleeve.

The axial overlap of the armature elements 102, 103 and the corresponding adjacent armature cylinder sleeves 22 and 26 in the starting position and the respective adjacent annular elements 25 and 31 in the starting position has been chosen so that the magnetic flux is optimized.

The gap widths S_1, S_2 are advantageously smaller than the longitudinal extension, in particular smaller than half the longitudinal extension of the annular elements 25, 31.

Each of the armature cylinder sleeves 26, 32 forms a stationary yoke element compared to the axially movable armature elements 102, 103, i.e. the stationary magnetic counterpart to the armature elements 102, 103. The armature cylinder sleeves 22 and 26 form conducting elements for the magnetic flux for the adjacent armature elements 102 and 103 in the starting position.

If the coil 47 is supplied with current in the starting position as shown in Fig. 2, magnetic lines of force 130 form toroidally around the coil body (Fig. 3). Depending on the polarity, they enter the first armature cylinder sleeve 22, e.g. from the base side, the armature element 102 thus bridging the radial gap 18 (parasitic gap between the armature cylinder sleeve 22 and the first armature element 102), leave the armature element 102 to a large extent in the area of the narrowest point between the armature element 102 and the second armature cylinder sleeve 26 (yoke element), run roughly axially in the second armature cylinder sleeve 26 up to the overlap area of the second armature element 103 and the second armature cylinder sleeve 26, enter the second armature element 103 by bridging the gap 108 (parasitic gap) between the armature cylinder sleeve 26 and the second armature element 103, leave the second armature element 103 analogous to the

first armature element 102 to a large extent at the narrowest point between the second armature element 103 and the third armature cylinder sleeve 32 and enter the third armature cylinder sleeve 32 (see Fig. 3).

As a result of this, the areas of the armature elements 102 and 103 (faces 111 and 115) and the armature cylinder sleeves 26 and 32 (piston lands 29 and 34) opposite the abovementioned narrow points are magnetized with opposite poles so that static magnetic forces F_{M1} and F_{M2} work on the armature element 102 and the armature element 103. The armature elements 102, 103 thus represent armatures in the sense of the abovementioned definition and the armature cylinder sleeves 26, 32 yoke elements in the sense of the abovementioned definition.

The total static magnetic force $F_M = F_{M1} + F_{M2}$ that works on the armature device 100 is much higher with the same input of electrical energy, due to the abovementioned magnetic series connection of the armature elements 102, 103 and the corresponding yoke elements 25 32, than a resulting magnetic force with an armature device that has a single armature element only. Thus, the output of the armature device 100 over a certain distance H along a direction of stroke 123 is correspondingly higher. In this respect, this leads to a better use of the magnetic energy generated by the coil 47 by means of a pre-defined input energy. Thus, the efficiency of a drive device of this type, with a multiple armature device 100 with armature elements 102 and 103 yoke elements corresponding to the armature elements 102 and 103, and thus the overall efficiency of a device 1 in accordance with the invention, is significantly improved.

It was seen that with two armature and yoke elements arranged typically for the design in such a device 1, the static magnetic force F_M could be increased in the most unfavorable case by at least 60% compared to the state-of-the-art with no additional input of electrical energy.

The gaps 121 and 122 extend in the working direction (direction of stroke 123) of the armature device 100. The widths S_1 and S_2 of these gaps determine the amount of the static magnetic forces that momentarily occur between the armature elements 102, 103 and the yoke elements (armature cylinder sleeves 26, 32) that operate along the path H of the armature device 100. In this respect they represent working gaps. The radial projection of the working gaps 121, 122 on the fixed radius, e.g. the radius of the inner surface of the armature cylinder sleeves 26, 22, 32, produces a working gap plane whose size depends on this radius and the corresponding gap widths S_1, S_2. With a given currently prevailing gap width S_1, S_2 of a working gap produced by a movement of the armature device 100, the size of the working gap is decisive for the magnetic force active between the yoke element and the armature element. The gap 109 extend with a width T vertical to the working direction (direction of stroke 123) of the armature device 100. No magnetic forces that perform work occur. Thus, these gaps 108 represent undesired "magnetic resistances" and are referred to as so-called "parasitic gaps". A minimization of the width T of these parasitic gaps 109 is desirable but limits are set by unavoidable production engineering tolerances.

The bigger the working gap plane at a given gap width S_1, S_2 of the working gap, the bigger the effective magnetic forces F_{M1} and F_{M2} on the armature elements 102, 103 at a given magnetic field strength.

Within the scope of the invention, the working gap plane was enlarged by a magnetic series connection of at least two armature-yoke arrangement so that at least two working gaps 121, 122 are formed.

In addition, the momentary magnetic force on an armature element 102, 103 of an armature-yoke arrangement (102, 26; 103, 34) depends on the width S of the momentary working gap 121, 122, so that the stroke path H can change the static magnetic forces on the armature elements 102, 103.

At a starting gap width S_1, S_2 the magnetic forces assume a certain value as described above. This value increases with a decreasing gap width S and reaches a maximum value at $S = 0$, which then drops again at $S < 0$, corresponding to an axial overlap between the armature and corresponding yoke element.

In this respect, the force curve of the overall force F_M can be altered over the stroke path H of the armature device 100 through the choice of working gap widths S_1, S_2 and it is thus easy to influence, in the manner described below, e.g. the spray characteristics, the pressure characteristic, the maximum injection volume flow or similar characteristics of the device 1. It is of course within the scope of the invention to make the working gap widths S_1 and S_2 identical or of different sizes. Moreover, the armature elements 102, 103 can be arranged at various positions adjustable in an axial direction on the armature carrier element 101.

In this respect, a device 1 in accordance with the invention enables not only drastically higher energy utilization of the input electrical energy by simple means, but also an increased variability of the device 1 with respect to various characteristic parameters of a generic device.

The mode of operation of the device to convey and/or spray free-flowing media, in particular fluids, in accordance with the invention will be explained in more detail in the following:

In an initial state, the coil 47 is currentless, the armature device 100 is in its starting position on the base side and the valve body 64 rests on the ribs 57a. There is a gap between the armature carrier element 101 and the valve body 64. The media to

be conveyed or sprayed is fed in through the feed device 66, preferably at an admission pressure, and enters the armature space 41 and base cavity 19 as well as the though bore 106 via the cross bore 71, the flood bore 70 and the bores 110 and 21. Excess media escapes through the bore 74 and drain device 73 so that the armature space 41 can be rinsed through with fresh medium. At the same time, fresh medium enters the pressure space 88 up to the stationary pressure valve 82 via the return valve 69 and the feed bore. Excess medium in the pressure space 88 passes the valve body 64 via the through bore 106 in the base cavity 19 and via the bores 21 into the armature space 41. Thus, the pressure space 88 can also be rinsed through with fresh medium when the valve, consisting of the valve body 64 and the delivery tube plunger 101, is open. Medium is present at stationary pressure between the stationary pressure valve 82 and the nozzle mouth.

If current is applied to the coil 47, a force F_M becomes effective on the armature device 100 that accelerates the armature device 100 with almost no resistance in the direction of delivery 5, whereby this stores kinetic energy. After a certain distance, the pressure space end 105 of the armature device 100 strikes against the valve body 64. When the armature device 100 hits the valve body 64 the pressure space 88 is hydraulically separated from the armature space 41 and the kinetic energy stored in the armature device 100 is transferred to the medium in the pressure space 88 in front of the armature carrier element 101 in the form of a pressure impact.

The pressure impact spreads through the medium and reaches the nozzle outlet by overcoming the stationary pressure valve 82.

The return valve 69 prevents the pressure impact from escaping in the feed direction 66. The injector needle 84 of the spray nozzle

element 83 opens when a pre-definable injection pressure is exceeded.

Depending on the ON duration of the coil current, the pressure impact conveying or spraying of the medium is followed by a displacement conveying or spraying of the medium when the armature device 100, in particular the armature carrier element 101, is moved further in the direction of delivery 5 in the pressure space 88.

If the coil current is switched off, the armature device 100 and the valve body 64 are returned to their starting positions by their pressure springs 120 and 89. The amount of medium that has been sprayed is fed into the pressure space 88 by the feed device 66 at an admission pressure.

In accordance with further embodiments the flow paths for the medium to be conveyed or sprayed, and the valve devices, are adjusted for conveying or spraying free-flowing media, e.g. dusty, granular, granulated or powdered media or fluids mixed with solids, e.g. sludges.

If a device 1 in accordance with the invention is to be used for intermittent conveying only, the spray nozzle device 83 can of course be omitted or replaced as necessary by a return valve device, e.g. similar to the stationary pressure valve 82.

In accordance with a further embodiment, each armature-yoke arrangement is assigned a separate drive magnet coil, each of which can also be electrically controlled separately as necessary. For practical purposes, the axial gap between the coils corresponds to that between the armature cylinder sleeves.

For a further optimization of the efficiency, the armature carrier element 101 in the area of the armature elements 102, 103 can be

made of a magnetic nonconductor, e.g. stainless steel to reduce the magnetic losses and at the end on the pressure space side of an impact-proof material. This prevents an unwanted course of the magnetic lines of force 130 over the armature carrier element.

Naturally, the scope of the invention also includes a device to convey and/or spray free-flowing media that works according to the energy storage principle, e.g. with resistanceless accelerated and abruptly braked media, and that has a drive device with a multiple armature-yoke arrangement.

In accordance with a further embodiment, a device 1 in accordance with the invention is designed as a double action device to convey and/or spray free-flowing media, in particular fluids, with reference to WO 96/34195.

Naturally, the annular elements 25, 31 of magnetically nonconducting material can also be designed as air gaps. It is also within the scope of the invention, for example, to design the carrier base tube wall 44 of the coil frame as an armature cylinder from a succession of magnetically conducting and magnetically nonconducting sleeve or annular elements.

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AMENDED PAGE

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Patent claims

1. A device to convey and/or spray free-flowing media, in particular fluids, which works in particular in accordance with the energy storage principle and which is designed as an electromagnetically powered reciprocating pump with a drive housing (2) in which an axially movable armature device (100) with an armature element (102) as drive element is borne in an armature cylinder (35) and the armature cylinder (35) is enclosed by a magnet coil (47) to generate the magnetic field necessary to drive the armature device (100) whereby the armature cylinder (100) has means (25) to interrupt a magnetic flux so that a magnetic flux from the magnet coil (47) can be generated via the armature cylinder (35), the armature element (102) and the drive housing (2), whereby there is an axial distance with the width (S_1) as a working gap (121) between the armature element (102) and an end of the means (25) to interrupt the magnetic flux in an initial state
characterized by the fact that
the armature device (100) displays at least one further armature element (103) at a distance (D) from the armature element (102) in the direction of delivery (5) and the armature cylinder (35) displays a further means (31) to interrupt the magnetic flux, whereby between the armature element (103) and one end of the means (31) to interrupt the magnetic flux there is an axial distance of the width (S_2) as a working gap (122).

2. Device in accordance with claim 1,
characterized by the fact that

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4.10.2001
M 4748 PCT/XI/dl

Patent claims

1. A device to convey and/or spray free-flowing media, in particular fluids, which works in accordance with the energy storage principle and is designed as an electromagnetically powered reciprocating pump with a drive housing (2) in which an axially movable armature device (100) with an armature element (102) as drive element is borne in an armature cylinder (35) and the armature cylinder (35) is enclosed by a magnet coil (47) to generate the magnetic field necessary to drive the armature device (100) whereby the armature cylinder (100) has means (25) to interrupt a magnetic flux so that am magnetic flux from the magnet coil (47) can be generated via the armature cylinder (35), the armature element (102) and the drive housing (2),
characterized by the fact that
the armature device (100) displays at least one further armature element (103) at a distance (D) from the armature element (102) in the direction of delivery (5) and the armature cylinder (35) displays a further means (31) to interrupt the magnetic flux, whereby between the armature elements (102, 103) and one end of the means (25, 31) to interrupt the magnetic flux there are axial distances of the widths (S_1, S_2) as working gaps (121, 122).

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the armature cylinder (35) consists of axially spaced, sequential armature cylinder sleeves (22, 26, 32) and the means (25, 31) to interrupt the magnetic flux are annular gaps or annular elements (25, 31) each of which are arranged between two armature sleeves (22, 26; 26, 32).

3. Device in accordance with claim 1 and/or 2,
characterized by the fact that
the widths (S_1, S_2) of the working gaps (121, 122) are of identical sizes.

4. Device in accordance with one or more of claims 1 to 3,
characterized by the fact that
the widths (S_1, S_2) of the working gaps (121, 122) are of different sizes.

5. Device in accordance with one or more of claims 1 to 4,
characterized by the fact that
at least one of the widths (S_1, S_2) of the working gaps (121, 122) is zero in the initial state

6. Device in accordance with one or more of claims 1 to 5,
characterized by the fact that
the armature elements (102, 103) are arranged at a fixed, in particular unchangeable distance (D) from each other on an armature carrier element (101), e.g. a delivery plunger tube.

7. Device in accordance with one or more of claims 1 to 5,
characterized by the fact that
the armature elements (102, 103) are arranged at an adjustable, fixed distance (D) from each another on an armature carrier element (101).

8. Device in accordance with one or more of claims 1 to 7,
characterized by the fact that
the armature elements (102, 103) display a cylindrical ring

disk shape each with a central bore (107, 108) with which they rest on the armature carrier element (1019 and have an axial longitudinal extension in such a way that the armature elements (102, 103) in the initial status each covers a partial section of the respective adjacent armature cylinder sleeves (22 and 26) and the means (25 and 31) to interrupt the magnetic flux which are positioned in front of these in the direction of delivery (5) so that the armature cylinder sleeves (22 and 26) each forms conducting elements for the magnetic flux to the corresponding armature elements (102 and 103) and the magnetic flux is optimized.

9. Device in accordance with claim 8,
characterized by the fact that
the widths (S_1, S_2) of the working gaps are smaller than the longitudinal extension, in particular smaller than half the longitudinal extension of the means (25, 31).

10. Device in accordance with claim 8 and/or 9,
characterized by the fact that
the armature elements (102, 103) have an outer diameter that is slightly smaller than the inner diameter of the armature cylinder sleeves (22, 26, 32) thus forming a radial play gap (109) of the width (T).

11. Device in accordance with one or more of claims 1 to 10,
characterized by the fact that
the armature elements (102, 103) and the armature cylinder sleeves (22, 26, 32) are made of an easily magnetizable material.

12. Device in accordance with one or more of claims 8 to 11,
characterized by the fact that
the armature elements (102, 103) each display at least one overflow bore (110) that runs parallel to the central bores (107, 108).

13. Device in accordance with one or more of claims 1 to 12, **characterized by the fact that** the annular elements (25 and 31) are made of a magnetic non-conductor or a material that conducts magnetic fluxes badly.

14. Device in accordance with one or more of claims 1 to 13, **characterized by the fact that** the device (1) to generate the magnetic field necessary to drive the armature device (100) has a number of axially successive magnet coils (47), in particular a number corresponding to the armature-yoke arrangement.

15. Device in accordance with claim 14, **characterized by the fact that** the coils (47) can be controlled separately.

16. Device in accordance with claim 14 and/or 15, **characterized by the fact that** the magnet coils (47) have an axial gap that corresponds to the distance (D) of the armature elements (102, 103) and the gap of the armature cylinder sleeves (26, 32).

17. Device in accordance with one or more of claims 1 to 16, **characterized by the fact that** the armature device (100) displays two armature elements (102, 103) and correspondingly the armature cylinder displays the two armature cylinder sleeves (26, 32) as yoke elements and the armature cylinder sleeve (22) as conducting element.

18. Device in accordance with one or more of claims 1 to 17,

characterized by the fact that
the drive housing (2), the armature cylinder, the armature device (100) and the coil (47) are rotationally symmetrical bodies which have a common central longitudinal axis (4) as a central axis.

19. Device in accordance with one or more of claims 1 to 18,
characterized by the fact that
one end of the armature cylinder is a guide piece (18) with a bearing bore (20) and the other end is a disk-shaped base piece with a central stepped bore (57) thus forming an armature space (41) whereby a guide cylinder (59) with a central through bore (62) aligned with the bearing bore (20) sits in an enlargement of the stepped bore (57) on the armature space side.

20. Device in accordance with claim 19,
characterized by the fact that
the ends of the armature carrier element (101) protrude beyond the armature elements (102, 103) with one end (104) borne in the bearing bore (20) and the second end (105) in the through bore (62) so that they can move axially, whereby a pressure spring (120) is arranged between the base part (50) and the armature element (103) that presses the armature device (100) against the guide piece (18) in the initial state.

21. Device in accordance with one or more of claims 8 to 20,
characterized by the fact that
the armature carrier element (10) is designed as a delivery plunger tube that is essentially a hollow cylindrical, long stretched-out body with an axial through bore (106) and whereby at least the front end (105) in the direction of delivery (5) forms a valve seat for a valve body (64) positioned at a distance in front of the end (105) in the direction of delivery.

22. Device in accordance with one or more of claims 1 to 21, **characterized by the fact that** the magnet coil (47) sits in a cable drum-shaped coil frame (43) with a cylindrical tube-shaped, carrier base tube wall (44) with boundary piston lands (45, 46) protruding radially from each end, whereby the coil frame (43) encloses and touches the armature cylinder with the carrier base tube wall (44).

23. Device in accordance with claims 1 to 21, **characterized by the fact that** the magnet coil (47) sits in a cable drum-shaped coil frame (43) with a cylindrical tube-shaped, carrier base tube wall (44) with boundary piston lands (45, 46) protruding radially from each end, whereby the carrier base tube wall (44) is designed as an armature cylinder.

24. Device in accordance with one or more of claims 1 to 23, **characterized by the fact that** the drive housing is pot-shaped and displays a thin-walled, cylinder jacket-shaped outside wall (6) and a thin-walled base wall (7) that closes the drive housing (2) on the end opposite to the direction of delivery (5) thus delimiting a drive housing inner space (8) whereby the base wall (7) has a number of steps radial to the central longitudinal axis (4) thus delimiting a base cavity (19) between the guide piece (18) and the base wall (7).

25. Device in accordance with one or more of claims 19 to 22,

characterized by the fact that
the base part (50) is part of a pump housing (3) that closes the front, open end of the pot-shaped drive housing (2) in the direction of delivery (5).

26. Device in accordance with claim 25,
characterized by the fact that
the base part (50) and pump housing (3) display a nozzle retaining cylinder (51) shaped as one piece on the base part (50) and protruding axially from this in the direction of delivery (5).

27. Device in accordance with one or more of claims 19 to 26,
characterized by the fact that
the through bore (57) that serves on a the armature space side as a location hole (57a) for the guide cylinder ends in a blind hole bore (58) delimited by the nozzle retaining cylinder (51) and enlarged compared to the stepped through bore (57) at its other end.

28. Device in accordance with claim 27,
characterized by the fact that
in the blind-hole bore (58) of the nozzle retaining cylinder (51) there are in the following order a pressure space end piece (80), a carrier piece (81) for a stationary pressure valve (82) and a spray nozzle element (83) with a spring-loaded injector needle (84) axial to the direction of delivery (5).

29. Device in accordance with claim 28,
characterized by the fact that
the pressure space end piece (80) has a pressure space bore (85) coaxial to the through bore (57) that tapers in one stage in the direction of delivery (5) to an overflow bore (86) to form an annular face (87).

30. Device in accordance with claim 29,
characterized by the fact that
the pressure space bore (85) and the through bore (87) delimit a pressure space (88) that ends in the overflow bore (86) at its end in the direction of delivery (5) and has ribs (57a) distributed radially around its circumference at its armature space end which protrude slightly into the pressure space (88) and serve as a support for the valve body (64).

31. Device in accordance with claims 29 and/or 30,
characterized by the fact that
there is a pressure spring (89) in the pressure space (88) one of whose ends rests on the face (87) and the other end on the valve body (64) so that the valve body (64) in its initial state is pressed against the ribs (63) on the armature space side.

32. Device in accordance with one or more of claims 27 to 31,
characterized by the fact that
the carrier piece (81) is placed axially against the pressure space end piece (80) and displays a multiple stepped through bore (90) that initially tapers in the direction of delivery (5) and then enlarges to form a pressure retention chamber (91) in which the stationary pressure valve is located on the pressure space side.

33. Device in accordance with claim 32,
characterized by the fact that
the stationary pressure valve (82) in the pressure space (88) maintains a certain minimum pressure in the medium in the pressure retaining chamber (91) and opens in the direction of delivery (5) as soon as a pressure higher than the standard pressure prevails in the pressure space (88).

34. Device in accordance with one or more of claims 19 to 33,

characterized by the fact that

the base part (50) and the pump housing (3) displays a multiple tapering feed bore (65) that runs radially from the outside to the inside and ends in the pressure space (88) whereby there is a feed device (66) in the feed bore (65) consisting of a hollow drilled feed nipple (67) and a return valve element (69) positioned radially inwards after this in the feed direction (68) that prevents the medium from flowing opposite to the feed direction (68).

35. Device in accordance with claim 34,

characterized by the fact that

a first flood bore (70) branches diagonally from the feed bore (65) radially outside the return valve element (69) one end of which ends in the armature space (41) and the other end of which is connected to the central bore of the feed nipple (67) via a cross bore (71).

36. Device in accordance with claim 34 and/or 35,

characterized by the fact that

the base part (50) and the pump housing (3) display a radial, blind hole-shaped drain bore (72) running radially from the outside to the inside that is preferentially opposite to the feed bore (65) whereby a drain nipple (73) sits in the drain bore (72) as a drain device and a second flood bore (74) branches diagonally from the base of the drain bore (72) ending in the armature space (41).

37. Device in accordance with claim 36,

characterized by the fact that

the feed nipple (67), the cross bore (71), the first flood bore (70), the armature space (41), the second flood bore (74), the drain bore (72) and the drain nipple (73) form a flow path in such a way that the armature space (41) can be continually rinsed through with fresh medium.

38. Device in accordance with one or more of claims 34 to 37, **characterized by the fact that** the feed nipple (67), return valve (69), tapered feed bore (65), pressure space (88) spaces between the ribs (63), through bore (106), the base cavity (19), through bores (21) of the guide piece (20), the overflow bores (110) of the armature elements (102, 103), the armature space (41), the second flood bore (74) and the drain nipple (43) form a flow path in such a way that the pressure space (88) can be rinsed through with fresh medium, as long as the end (105) of the armature carrier element (101) that forms a valve face displays a distance to the valve body (64) and thus can be enables a discontinuous flow.

39. Device in accordance with one or more of claims 30 to 38, **characterized by the fact that** the pressure space (88) is hydraulically separated from the armature space (41) as soon as the armature carrier element (101) touches the valve body (64) whilst moving in the direction of delivery (5) so that the kinetic energy stored in the armature element (100) is transferred to the medium in the pressure space (88) in the form of a pressure impact.

40. Device in accordance with one or more of claims 1 to 39, **characterized by the fact that** flow paths for the medium to be conveyed or sprayed as well as the valve devices are adjusted to the conveying or spraying of free-flowing media, e.g. dusty, granular, granulated or powdered media of fluids mixed with solids, e.g. sludges.

41. Device in accordance with one or more of claims 6 to 40, **characterized by the fact that** the armature carrier element (101) in the area of the armature elements (102, 103) is made of a magnetic nonconductor, e.g. stainless steel and of an impact-proof material at the end on the pressure space side.

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Summary

The invention concerns a device to convey and/or spray free-flowing media, in particular fluids, which works in accordance with the energy storage principle and is designed as an electro-magnetically powered reciprocating pump with at least one armature device 100 as a drive element, whereby the armature device 100 displays at least two armature elements 102, 103 and the armature elements 102, 103 are assigned magnetically corresponding yoke elements 26, 32.

I certify that the above is a true and complete translation of the original.
Friday, February 22, 2002.

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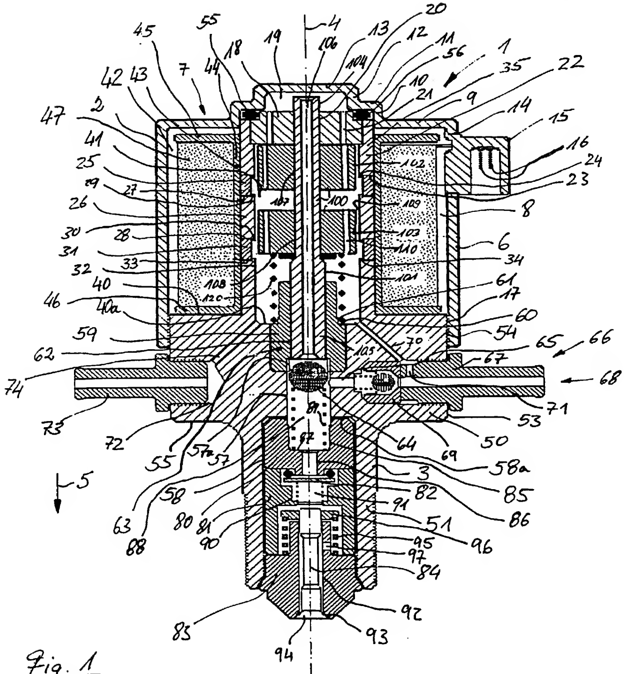

Fig. 1

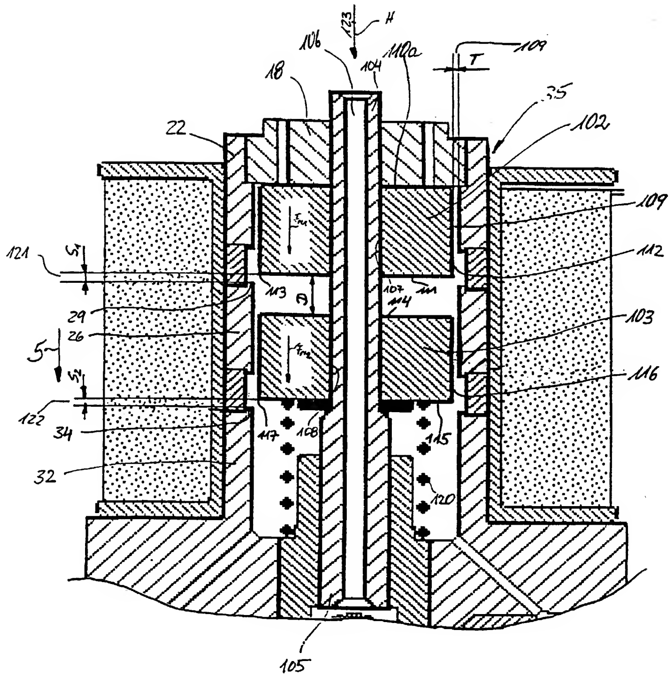
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Fig. 2

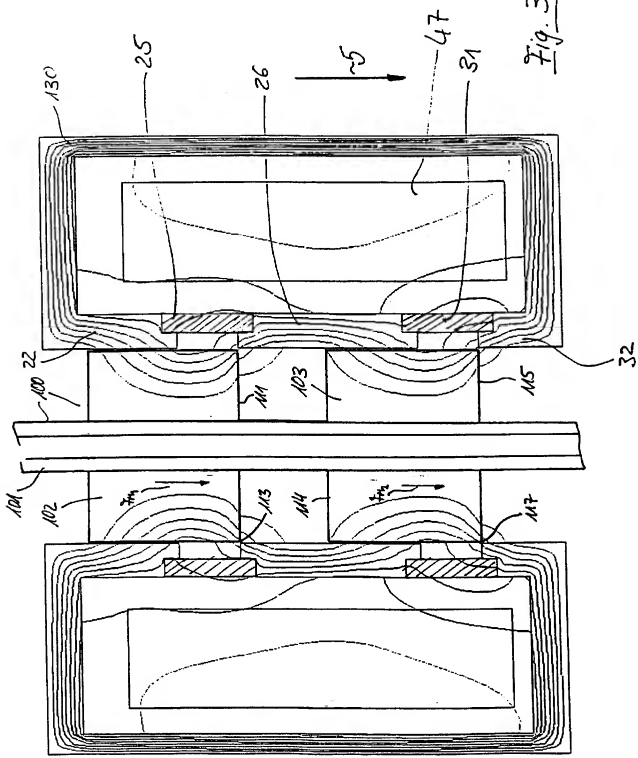

Fig. 3

Declaration and Power of Attorney for Patent Application
Erklärung für Patentanmeldungen mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

daß mein Wohnsitz, meine Postanschrift und meine Staatsangehörigkeit den im nachstehenden nach meinem Namen aufgeführten Angaben entsprechen, daß ich nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent für die Erfindung mit folgendem Titel beantragt wird:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

DEVICE FOR DELIVERING AND/OR SPRAYING FLOWABLE MEDIA, ESPECIALLY FLUIDS

deren Beschreibung hier beigefügt ist, es sei denn (in diesem Falle Zutreffendes bitte ankreuzen), diese Erfindung

☐ wurde angemeldet am ______ unter der US-Anmeldenummer oder unter der Internationalen Anmeldenummer im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT) ______ und am ______ abgeändert (falls zutreffend).

the specification of which is attached hereto unless the following box is checked:

☐ was filed on ______ as United States Application Number or PCT International Application Number ______ and was amended on ______ (if applicable).

Ich bestätige hiermit, daß ich den Inhalt der oben angegebenen Patentanmeldung, einschließlich der Ansprüche, die eventuell durch einen oben erwähnten Zusatzantrag abgeändert wurde, durchgesehen und verstanden habe.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Titel 37, Code of Federal Regulations, § 1.56 von Belang sind.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

German Language Declaration

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäß Title 35, US-Code, § 119 (a)-(d), bzw. § 365(b) aller unten aufgeführten Auslandsanmeldungen für Patente oder Erfinderurkunden, oder §365(a) aller PCT internationalen Anmeldungen, welche wenigstens ein Land ausser den Vereinigten Staaten von Amerika benennen, und habe nachstehend durch ankreuzen sämtliche Auslands- anmeldungen für Patente bzw. Erfinderurkunden oder PCT internationale Anmeldungen angegeben, deren Anmeldetag dem der Anmeldung, für welche Priorität beansprucht wird, vorangeht.

I hereby claim foreign priority under Title 35, United States Code, §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Applications
(Frühere ausländische Anmeldungen)

(Number) (Nummer)	(Country) (Land)	(Day/Month/Year Filed) (Tag/Monat/Jahr der Anmeldung)	Priority Not Claimed / Priorität nicht beansprucht
199 37 988.2	Germany	11/ 08 / 1999	☐
			☐

Ich beanspruche hiermit Prioritätsvorteile unter Title 35, US-Code, § 119(c) aller US-Hilfsanmeldungen wie unten aufgezählt.

I hereby claim the benefit under Title 35, United States Code, § 119(c) of any United States provisional application(s) listed below.

(Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)

Ich beanspruche hiermit die mir unter Title 35, US-Code, § 120 zustehenden Vorteile aller unten aufgeführten US-Patentanmeldungen bzw. § 365(c) aller PCT internationalen Anmeldungen, welche die Vereinigten Staaten von Amerika benennen, und erkenne, insofern der Gegenstand eines jeden früheren Anspruchs dieser Patentanmeldung nicht in einer US-Patentanmeldung, bzw. PCT internationalen Anmeldung in in einer gemäß dem ersten Absatz von Title 35, US-Code, § 112 vorgeschriebenen Art und Weise offenbart wurde, meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Title 37, Code of Federal Regulations, § 1.56 von Belang sind und die im Zeitraum zwischen dem Anmeldetag der früheren Patentanmeldung und dem nationalen oder im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesen (PCT) gültigen internationalen Anmeldetags bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)	(Status) (patented, pending, abandoned) (Status) (patentiert, schwebend, aufgegeben)
pct/ep00/07210	July 26, 2000	Pending

Ich erkläre hiermit, daß alle in der vorliegenden Erklärung von mir gemachten Angaben nach bestem Wissen und Gewissen der Wahrheit entsprechen, und ferner daß ich diese eidesstattliche Erklärung in Kenntnis dessen ablege, daß wissentlich und vorsätzlich falsche Angaben oder dergleichen gemäß § 1001, Title 18 des US-Code strafbar sind und mit Geldstrafe und/oder Gefängnis bestraft werden können und daß derartige wissentlich und vorsätzlich falsche Angaben die Rechtswirksamkeit der vorliegenden Patentanmeldung oder eines aufgrund deren erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that those statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

VERTRETUNGSVOLMACHT: Als benannter Erfinder beauftrage ich hiermit den (die) nachstehend aufgeführten Patentanwalt (Patentanwälte) und/oder Vertreter mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Angelegenheiten vor dem US-Patent-und Markenamt: *(Name(n) und Registrationsnummer(n) auflisten)*

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: *(list name and registration number)*

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2 Vor- und Zuname des zweiten Miterfinders (falls zutreffend) Klaus-Jürgen PETER	Full name of second joint inventor, if any
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Fifth inventor's signature	Date
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Citizenship	
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